Great White Sharks
PREDATORS IN PERIL

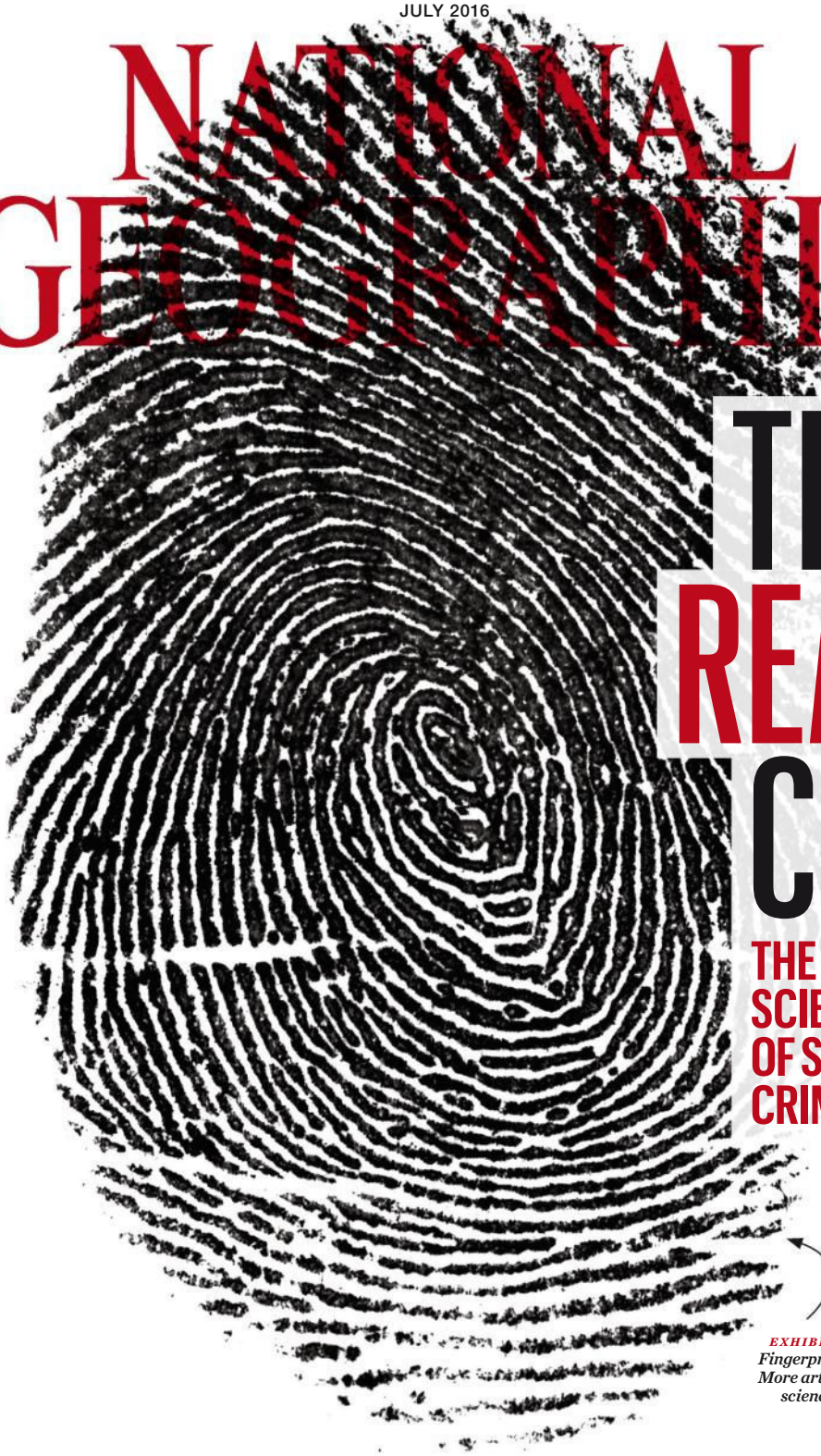
Saving Africa's Oldest Park

The Gods of Ancient Greece

EXPLORER
Watch 'Battle for Virunga' Sunday, June 26, on the National Geographic Channel

JULY 2016

NATIONAL GEOGRAPHIC



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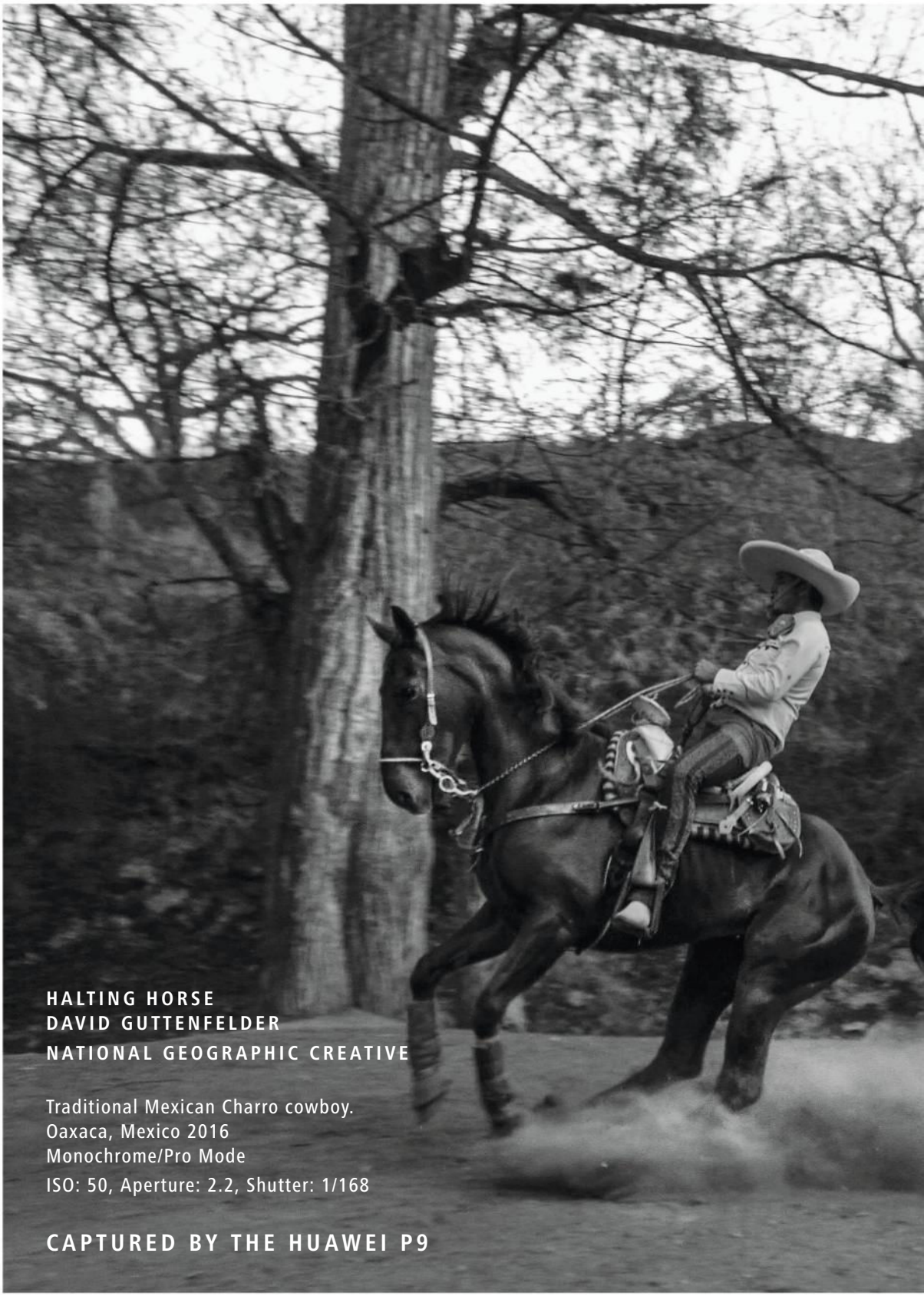
THE NEW SCIENCE OF SOLVING CRIME

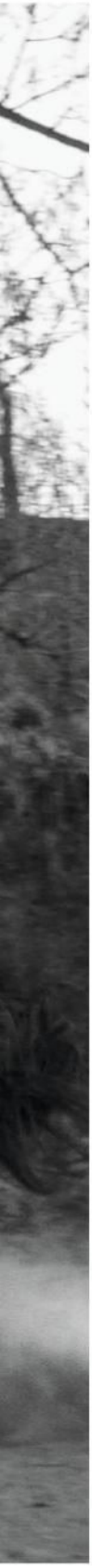
EXHIBIT A
Fingerprints? More art than science.



HALTING HORSE
DAVID GUTTENFELDER
NATIONAL GEOGRAPHIC CREATIVE

Traditional Mexican Charro cowboy.
Oaxaca, Mexico 2016
Monochrome/Pro Mode
ISO: 50, Aperture: 2.2, Shutter: 1/168

CAPTURED BY THE HUAWEI P9



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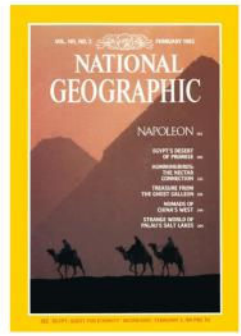
NATIONAL GEOGRAPHIC

JULY 2016 • VOL. 230 • NO. 1

Even in shark-filled waters like these, near Australia's Neptune Islands, no one has ever seen great white sharks mate or give birth.

On the Cover Fingerprint analysis, which investigators have used to help solve crimes since the late 1800s, is now being reevaluated, along with other forensic science practices. *Photo by ar-chi/Getty Images*

Corrections and Clarifications Go to *ngm.com/corrections.*



Digital technology has simplified the alteration of images, such as moving a pyramid to make a horizontal image (left) fit on a vertical cover (above).

How We Check What You See

In the digital age, when it's easy to manipulate a photo, it's harder than ever to ensure that the images we publish, whether on paper or on a screen, reflect the reality of what a photographer saw through his or her viewfinder. At *National Geographic,* where visual storytelling is part of our DNA, making sure you see real images is just as important as making sure you read true words.

I'll explain how we strive to keep covertly manipulated images out of our publications—but first an admission about a time when we didn't. Longtime readers may remember.

In February 1982 the magazine's cover showed a camel train in front of the Pyramids at Giza. The image produced by the photographer was horizontal; here at headquarters we altered the photo to fit our vertical cover. That change visually moved the pyramids closer together than they really are.

A deserved firestorm ensued—"*National Geographic* moves the pyramids!" came the outcry. We learned our lesson. At *National Geographic* it's never OK to alter a photo. We've made it part of our mission to ensure our photos are real.

I went to our expert to explain how we do this. Sarah Leen is director of photography at *National Geographic* and has been here for 30 years. A few decades ago it was easier to spot photo manipulation because the results were a lot cruder. Now, she says, "you can't always tell if a photo is fake, at least not without a lot of forensic digging." Even our experts can be fooled, as in 2010 when we published what we later learned was a doctored photo from a contributor to Your Shot *(yourshot.ngm.com)*.

We work with the most admired photographers in the world, but just like we require our writers to provide their notes, we require photographers on assignment to submit "raw" files of their images, which contain pixel information straight from the digital camera's sensor. We request the same for Your Shot photos sent in by members of the public or stock images we buy. If a raw file isn't available, we ask detailed questions about the photo. And, yes, sometimes what we learn leads us to reject it.

Still, reasonable people can disagree: One of our photographers recently entered a photo in a contest. It was rejected as being overprocessed; our editors, on the other hand, saw the same photo and thought it was OK. We published it. Were we right, or were the contest judges right? That's a subject we can continue to discuss.

"We ask ourselves, 'Is this photo a good representation of what the photographer saw?'" Leen says. For us as journalists, that answer always must be yes.

Thank you for reading *National Geographic.*

Susan Goldberg, *Editor in Chief*

PHOTO: GORDON GAHAN, NATIONAL GEOGRAPHIC CREATIVE

'I'iwi *(Drepanis coccinea)*
Size: Body length, approx. 15 cm (5.9 inches) **Weight:** 16.7 - 19.9 g (0.6 - 0.7 oz) **Habitat:** Prefers wet to mesic forest for breeding, but also visits dry areas **Surviving number:** Estimated at 605,418 in 2012

Photographed by Cathy & Gordon Illg

WILDLIFE AS CANON SEES IT

Say aloha to an icon. The 'i'iwi is recognized as a symbol of Hawai'i, and was once common on all the main islands of the archipelago. Now found primarily on Kaua'i and Hawai'i Island, the honeycreeper will fly long distances to find its favorite blooming flowers. An important pollinator, it uses its long, hooked bill to extract nectar from elaborately shaped flowers. The 'i'iwi defends territory during blooming peaks, but is powerless in the face of avian malaria, introduced predators and habitat degradation.

As Canon sees it, images have the power to raise awareness of the threats facing endangered species and the natural environment, helping us make the world a better place.

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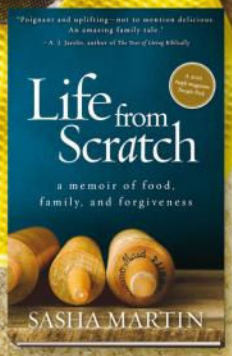
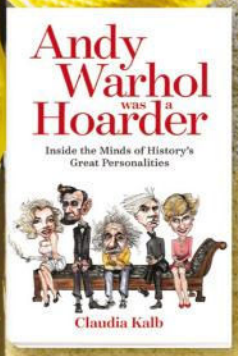
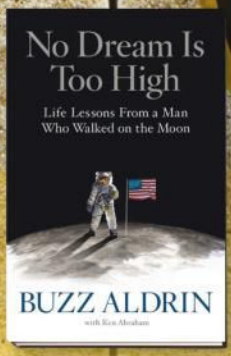
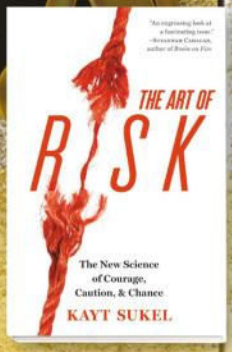
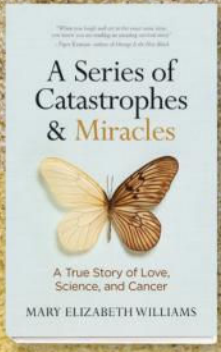




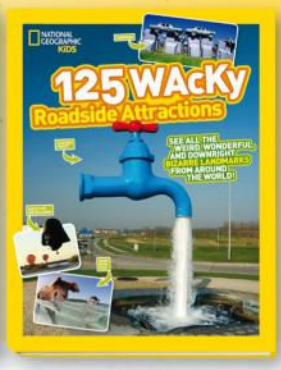






Summer READS

Be awed, be moved, be surprised with great books from National Geographic



FOR KIDS!

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Why Climbing Is Like Filmmaking

Jimmy Chin's parents were "mortified" when he moved to Yosemite National Park to live in the back of his car after college. Now 42, Chin's a *Geographic* photographer, trailblazing ski mountaineer, and award-winning filmmaker. He produced, directed, shot, and starred in *Meru,* about making a brutal ascent in India; it won the U.S. Documentary Audience Award at the 2015 Sundance Film Festival. Finally, Chin says, his parents have warmed to his career choice.

When did mountaineering become your path? Between the expectations of my Chinese immigrant parents and society, there was a picture of what life is supposed to be. I decided if I was going to climb, I was going to take it as far as I could, so I put together an expedition to the Charakusa Valley in Pakistan in 1999. It's still one of the greatest adventures of my life. You can never re-create your first expedition exactly—that sense of a total adventure. But every expedition feels like I'm going into the unknown. I still get the butterflies.

What did it feel like to ski off Mount Everest's summit? It wasn't really emotionally climactic until after we got down to base camp two days later. We were starting to hike out of the valley, and I looked up and could see the summit. It was one of those very rare moments in my life where I felt completely gratified, satisfied, and content. For a moment I let myself enjoy it, but there's always something more. Those kinds of pinnacle experiences only come from dreaming big and thinking of things that seem unattainable. And then you try.

How do you incorporate filmmaking? Climbing mountains is all about efficiency; every wasted effort is very expensive. So when you're shooting on top of climbing, sometimes it feels exponential. But nothing great comes easily: It can be climbing a mountain, making a film, writing a book, or getting a degree. Making films is a lot like climbing mountains, but the nice thing about films is they outlive you.

PHOTO: MARCO GROB

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VISIONS

Thailand
In Chiang Mai, floating lanterns set the night alight during the annual Yi Peng festival. The tradition, rooted in Buddhism, emphasizes reflection and spiritual cleansing. The lit lanterns, or *khom loi,* are hot-air balloons made of rice paper.

PHOTO: PANUPONG ROOPYAI, DEMOTIX/CORBIS

United States
Against a velvet backdrop in a South Carolina lab tank, a mushroom coral resembles a blooming flower. These invertebrates are used for tissue explants, a type of plant propagation. Eighteen photos were stitched together to make this composite.

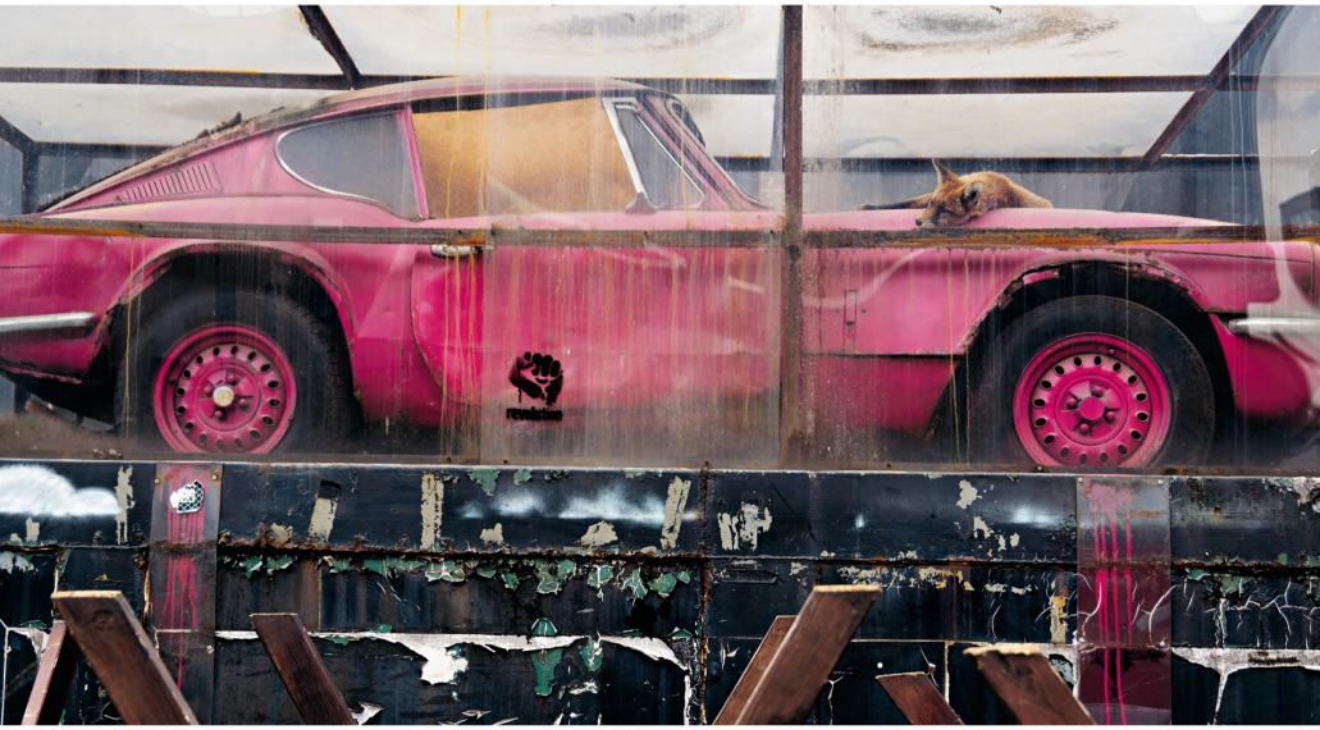
PHOTO: JAMES H. NICHOLSON, NOAA

Japan
Seen from below, an autumn blaze of maple leaves is veined by a crooked lattice of trunks and branches at Shinjuku Gyoen National Garden. The Tokyo site is a hot spot for *momijigari,* the centuries-old Japanese tradition of viewing fall foliage.

PHOTO: DANNY DUNGO

Urban Wildlife

Assignment We asked Your Shot members to explore their cities and show us a fresh perspective on the wild animals living within them.



EDITOR'S NOTE

'With the thousands of images submitted for this assignment, the Your Shot community created more than a photo story; it took a step toward giving these urban species their "wild" identity back.'

Prasenjeet Yadav, *Your Shot photo editor*

Eduard Florin Niga
London, England

Protected by a clear box on East London's bustling Brick Lane, this pink-painted sports car—a creation of the street artist Banksy—tends to draw crowds, says Niga. So he was surprised to see a fox "so relaxed and at ease" resting atop its hood.

Mark Bridger
Offham, England

"It's a bit strange to see an animal you normally associate with woodland wandering the streets," says Bridger, who photographed this herd of deer in the early hours of the morning in an Essex housing development.

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EXPLORE

Us

The Science of Curls

If you've tangled with a headful of ringlets, crimps, or coils, rest assured: It's not just you. Even physicists and engineers can be stumped by curly hair. But with computer and lab studies, they're learning why a curled, flexible material like hair behaves as it does and how to handle it.

How a hair shaft curves is influenced by the interplay among gravity, texture, and the follicle from which the hair grows. Asymmetrical follicles yield hair that curls, symmetrical follicles yield straight hair. The longer curly hair grows, the more complex its structure can be, says a study reported in a journal of the American Physical Society. Although straight hair generally follows a linear course as it emerges from the scalp, curly hair can spiral up or down or even double back on itself.

This unique geometry could make curly hair particularly vulnerable to heat during styling. At Purdue University researchers are investigating how straighter hair may conduct heat better, making it less prone to burning than curly hair. The Purdue team's goal: to determine which styling temperatures maximize hair health. —*Nicole Washington*

PHOTOS: REBECCA HALE, NGM STAFF

Top: The fabled flitch. At press time, it had not been awarded for 2016. Right: Mr. and Mrs. C. J. R. Faulkner, of Great Easton, Essex, brought home the bacon in 1951. For the 2016 trials, five contestant couples, called claimants, were selected after persuasively filling out a three-page application.

Half-Hog Harmony

Since the Middle Ages, when Geoffrey Chaucer wrote *The Canterbury Tales,* much in "Engelond" has changed. All that's left of the Tabard Inn, the staging area for Chaucer's pilgrims, is a historical marker.

But a nuptial custom referenced by the much wed Wife of Bath has survived from the 12th century to the 21st. The Dunmow Flitch Trials, set for July 9, award a flitch of bacon—half a pig, cut lengthwise—to the couple who can best convince a jury that they haven't wished themselves unmarried for the past year and a day. (The Wife of Bath implied her browbeaten husbands would not qualify.)

Legend says that the custom originated in 1104. Now the trials, in Great Dunmow, northeast of London, take place every leap year. Flitch owners and contestants are represented by counsel. Winners are paraded through town on the shoulders of costumed folk and must then kneel on sharp stones to receive the Flitch Oath. When Americans Jeff Dotts and Erin Albers won the flitch in 2008, the oath was read "incredibly slowly," Dotts recalls, "in a sort of sadistic, British jab" at the unpleasantness of 1776. He says the trials are taken "very seriously" but with a wink.

Indeed. Take the selection of counsel: "This year," spokesperson Helen Haines reports, "we have three actual barristers and one stand-up comedian." *—Martin F. Kohn*

PHOTOS: HOMER SYKES, ALAMY (TOP); ANTHONY WALLACE, ANL/REX/SHUTTERSTOCK

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Patterns Puzzle Predators

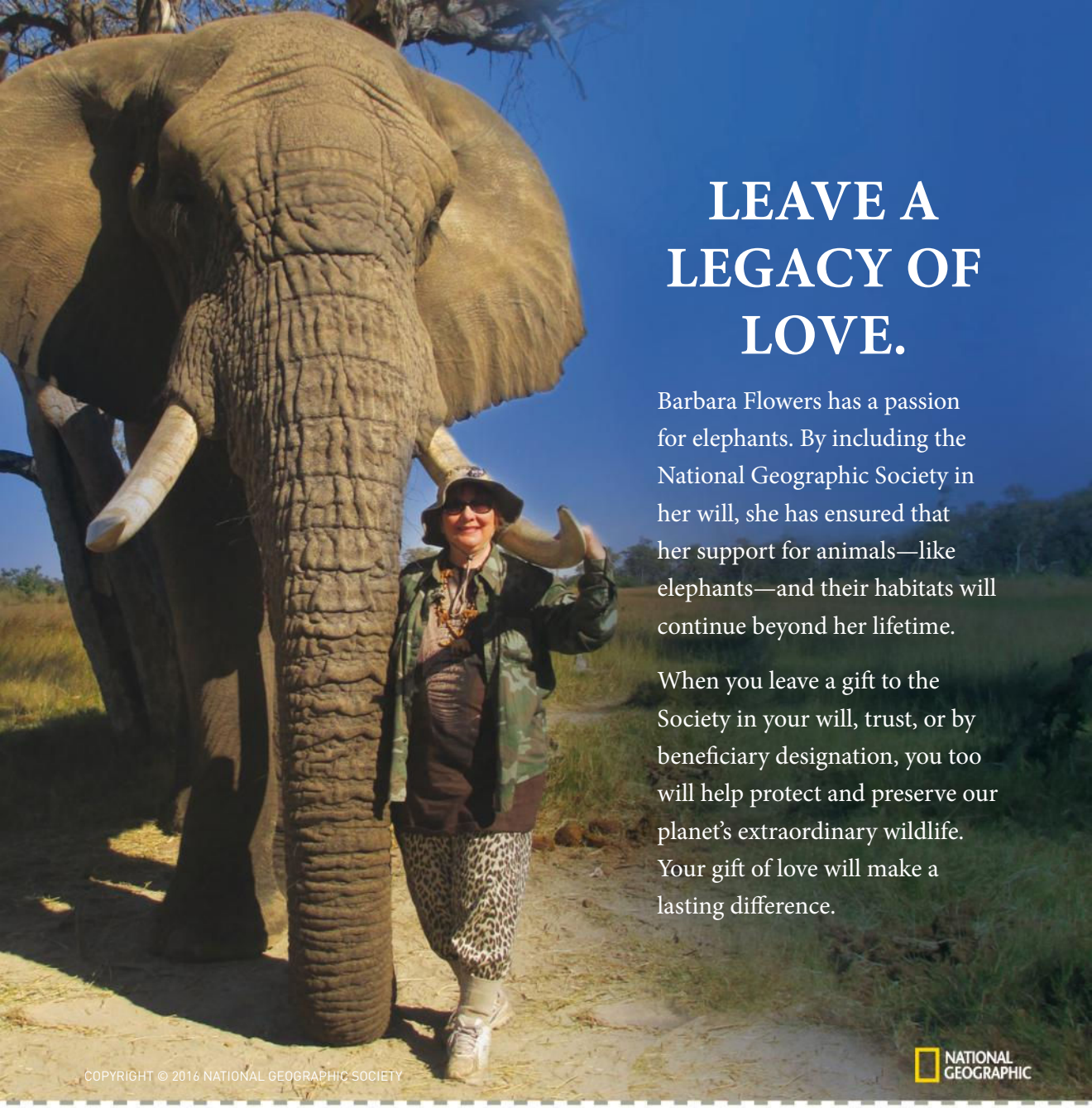
If a zebra zigs, will its stripes make a predator zag? That's the idea behind motion dazzle, a century-old hypothesis about why some animals sport high-contrast patterns. Unlike camouflage, which allows prey to blend into surroundings, motion dazzle may mask movement, confusing predators about direction and speed. "We have all these ideas about animal patterns," says Cambridge University biologist Laura Kelley, "but very few of these hypotheses have actually been tested."

To find out whether patterns make prey difficult to catch, Kelley and her colleagues have developed an online game with humans as the predators. Dazzle Bug players try to nab patterned "bugs" skittering across natural backgrounds. The easy-to-catch critters disappear; the evasive ones reproduce. Eventually only the hardest-to-catch patterns remain. Says Kelley, "We're trying to determine the ideal pattern for avoiding capture during movement." *—Rachel Hartigan Shea*

BATS WITH BENEFITS

Perhaps no mammal is as misunderstood as the bat. Often portrayed as scary bloodsuckers, bats are actually gentle, intelligent animals that are more helpful than harmful to humans. Case in point: They save the global corn industry more than a billion dollars a year by eating a crop-killing moth, says a recent study funded by Bat Conservation International. Led by ecologist Josiah Maine, the study estimated that kernel damage rises by some 50 percent when bats are kept from foraging near cornfields. "Many people have a fear of bats," says Maine, "but they provide a valuable service." *—Catherine Zuckerman*

PHOTOS: MARTIN HARVEY, CORBIS (TOP); MICHAEL DURHAM, MINDEN PICTURES/NATIONAL GEOGRAPHIC CREATIVE



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Among Thoreau's blooms (clockwise from top left): pitcher plant, bluet, sheep laurel, and pink lady's slipper

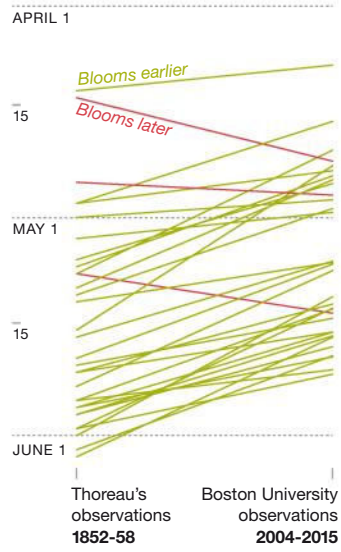
Walden's Climate Changes

"I am on the alert for the first signs of spring," wrote Henry David Thoreau. The author of *Walden* recorded first flowering times from 1852 to 1858 for more than 300 plant species in Concord, Massachusetts. During his daily wanderings through field and forest, he also noted when migrating birds returned, when leaves burst forth on trees, and when the ice melted on Walden Pond.

Some 160 years later, Richard Primack, a biologist at Boston University, is using Thoreau's handwritten data to track how the climate has changed in this historically significant corner of New England. In 2004 Primack and his students began scouring Concord for first flowerings. "We didn't know where to look," says Primack, until they learned Thoreau's trick of seeking early blooms in areas of human disturbance. The 19th-century thinker found his quarry along railroad tracks; Primack and his crew had luck near Walden's parking lot.

Primack's ongoing study confirms that a warming climate—Concord is up 5°F—is hastening the signs of spring. Walden's ice breaks up and many plants bloom at least two weeks earlier than in Thoreau's day, while leaves emerge on trees 18 days earlier. Only the migrating birds return at roughly the same time. How will this confluence of change alter the local ecosystem? To know that, Thoreau noted, one would have to "anticipate … Nature herself!" *—Rachel Hartigan Shea*

Date of first flowering
Averages for 32 wildflower species



PHOTOS: TIM LAMAN
GRAPHIC: NGM STAFF. SOURCE: RICHARD PRIMACK, BOSTON UNIVERSITY

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- panic attacks
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- acting on dangerous impulses
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- Are breastfeeding or plan to breastfeed. LYRICA passes into your breast milk. It is not known if LYRICA can harm your baby. Breastfeeding is not recommended while taking LYRICA.

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal supplements. LYRICA and other medicines may affect each other causing side effects. Especially tell your doctor if you take:

BEFORE STARTING LYRICA, continued

- Angiotensin converting enzyme (ACE) inhibitors. You may have a higher chance for swelling and hives.
- Avandia® (rosiglitazone)*, Avandamet® (rosiglitazone and metformin)* or Actos® (pioglitazone)** for diabetes. You may have a higher chance of weight gain or swelling of your hands or feet.
- Narcotic pain medicines (such as oxycodone), tranquilizers or medicines for anxiety (such as lorazepam). You may have a higher chance for dizziness and sleepiness.
- Any medicines that make you sleepy.

POSSIBLE SIDE EFFECTS OF LYRICA

LYRICA may cause serious side effects, including:
- See "Important Safety Information About LYRICA."
- Muscle problems, pain, soreness or weakness along with feeling sick and fever
- Eyesight problems including blurry vision
- Weight gain. Weight gain may affect control of diabetes and can be serious for people with heart problems.
- Feeling "high"

If you have any of these symptoms, tell your doctor right away.
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- Sleepiness
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- Swelling of hands and feet
- Dry mouth

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HOW TO TAKE LYRICA

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The World in 1550

French admiral Claude d'Annebault knew his political career was in trouble. Once a top adviser to King Francis I, he fell out of favor after Henry II inherited the throne. What to do? He decided that a magnificent gift—a lavish map of the world—might maneuver him into the new king's good graces.

D'Annebault hired Pierre Desceliers, one of the best cartographers of his day, for this project. Directing a team of artists, Desceliers produced the illustrated, annotated map seen here, full of geographic features both real and imagined. "It's one of the most beautiful maps to have survived from the Renaissance," says Chet Van Duzer, a historian of cartography. And it's so large, about five by seven feet, that it covers several pieces of parchment. Van Duzer's new book, *The World for a King,* reproduces the map in the original colors and at full scale—in 42 sections—for the first time. His research found that Desceliers took most of his descriptive texts from two books. One was the 1522 edition of the *Geography* of Claudius Ptolemy, the other a collection of historical narratives whose authors included Marco Polo and Christopher Columbus.

It's impossible to know for sure if this extravagant present had the desired effect, but it's tempting to think it did. D'Annebault returned to favor briefly before his death in 1552. *—A. R. Williams*

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South Africa

Need help to find a long-lost human ancestor? Try Facebook.

MARINA ELLIOTT *Nat Geo emerging explorer*

In October 2013 Marina Elliott answered a mysterious Facebook ad seeking experienced archaeologists and paleontologists with a specific physique: "The person must be skinny and preferably small," it read.

The next month, Elliott was squeezing through an eight-inch-wide passage into a South African cave filled with fossils of a previously undiscovered human relation: *Homo naledi.*

Paleoanthropologist Lee Berger had posted the request for diminutive team members to excavate a cave in the Cradle of Humankind, a World Heritage site outside Johannesburg where many important human fossils had been discovered. Elliott, then a biological anthropology Ph.D. student in Canada, was a sport climber and had done fieldwork in the inhospitable terrains of Siberia and northern Alaska.

She was the first of the six chosen scientists to slide into the chamber where climbers had initially spotted fossils. The passage was so narrow that there wasn't room to wear a safety harness. "We thought, There's just one skeleton. We'll dig it out and then all go out and live our lives," she recalls. "But the first time I went in it really hit me what we were dealing with. I shone my headlamp around the chamber, and everywhere it shone I could see pieces of bone." Each fossil was carefully wrapped and relayed along a chain of scientists and cavers to the surface. After three weeks they had unearthed 1,550 fossils belonging to 15 different individuals and had added a branch to humankind's family tree.

Marina Elliott descends into a cave where archaeologists unearthed *Homo naledi,* a previously unknown cousin of humans. The route's "pinch point" was less than eight inches wide.

After finishing her degree, Elliott moved to South Africa to continue excavating and analyzing the materials and dating the bones with Berger. Ten years earlier, a class on human origins had inspired her to abandon a career in veterinary medicine and become an anthropologist. Now future students will likely read of her discoveries. *—Nina Strochlic*

Sri Lanka

The unorthodox whale watcher

ASHA DE VOS *Nat Geo emerging explorer*

Asha de Vos likes to say her career started with a pile of feces. In 2003 the marine biologist was working on a research boat off the Sri Lankan coast when she saw excrement float to the

PHOTO: ELLIOT ROSS. NGM MAPS

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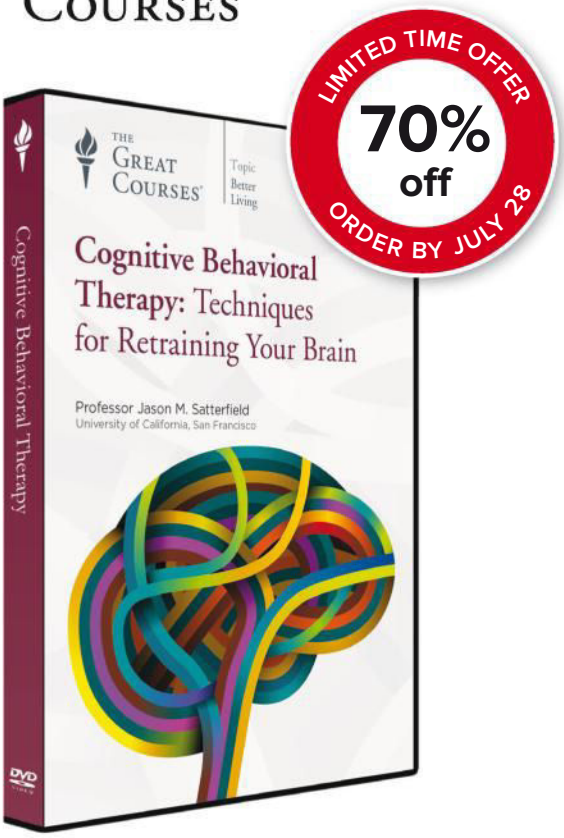

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surface. Six blue whales were swimming below in a narrow area within a busy shipping lane. Upon further investigation, de Vos realized that the whales were staying put instead of migrating to waters with richer food sources. Theorizing that they were an unrecognized unique population, she dubbed them the "unorthodox whales." She also discovered that vessels moving to and from the port were often striking the creatures, sometimes fatally. In 2008 she set up the Sri Lankan Blue Whale Project to advocate for the protection of the whales and their North Indian Ocean habitat.

"My friends say I'm as unorthodox as the animals I study," says de Vos, who is the first Sri Lankan to get a Ph.D. in marine mammal research. Despite being both highly educated and dedicated, she struggled for years to break into the conservation field in Sri Lanka. "People didn't take me seriously because I was too young and too female, which for me is a compliment," de Vos says. "Even now people say, 'When are you getting married?' Well, first I have a whole ocean to save."

In 2011 a video highlighting de Vos's work went viral, and her country started taking action. Recently, she was asked to be an adviser to the Ministry of Sustainable Development and Wildlife, which she sees as a chance to solidify conservation efforts. Sri Lanka, she says, "can be an example for marine sustainability in the developing world." *—Nina Strochlic*

Years of advocating for Sri Lanka's blue whales is paying off, Asha de Vos says. The nation's government is taking steps to protect whales from the threats posed by shipping vessels.

PHOTO: BRET HARTMAN. NGM MAPS

Democratic Republic of the Congo

Save a gorilla, save a country

BRENT STIRTON *Photographer*

Stirton reports: In 2007 I made a photograph of a mountain gorilla that had been killed in Virunga National Park, and it got an astonishing response. That woke me up. I've come to believe that we need to care about the animals and spaces on our planet as much as the human beings—they can't be separated.

Virunga could be the key to peace in eastern Congo, but rebels, foreign oil prospectors, illegal farming, and political instability threaten it. Managing this is comparable with fighting a war. I've watched the warden, Emmanuel de Merode, negotiate with two different rebel groups who occupied the park. In 2014 he was shot in the chest and stomach by gunmen. A month later he was back at work. This March three rangers were killed. I've been there when a ranger was killed, but it's impossible to photograph the full extent of what they face. More than 150 have lost their lives in the past 20 years. Imagine being two men surrounded by 120 heavily armed rebels.

The gorilla caretakers are also remarkable: They spend far more time at the sanctuary than with their own families and illustrate what a relationship between animals and humans could be. Virunga is a metaphor for what's possible in Congo: If the park is allowed to thrive, it will transform the country.

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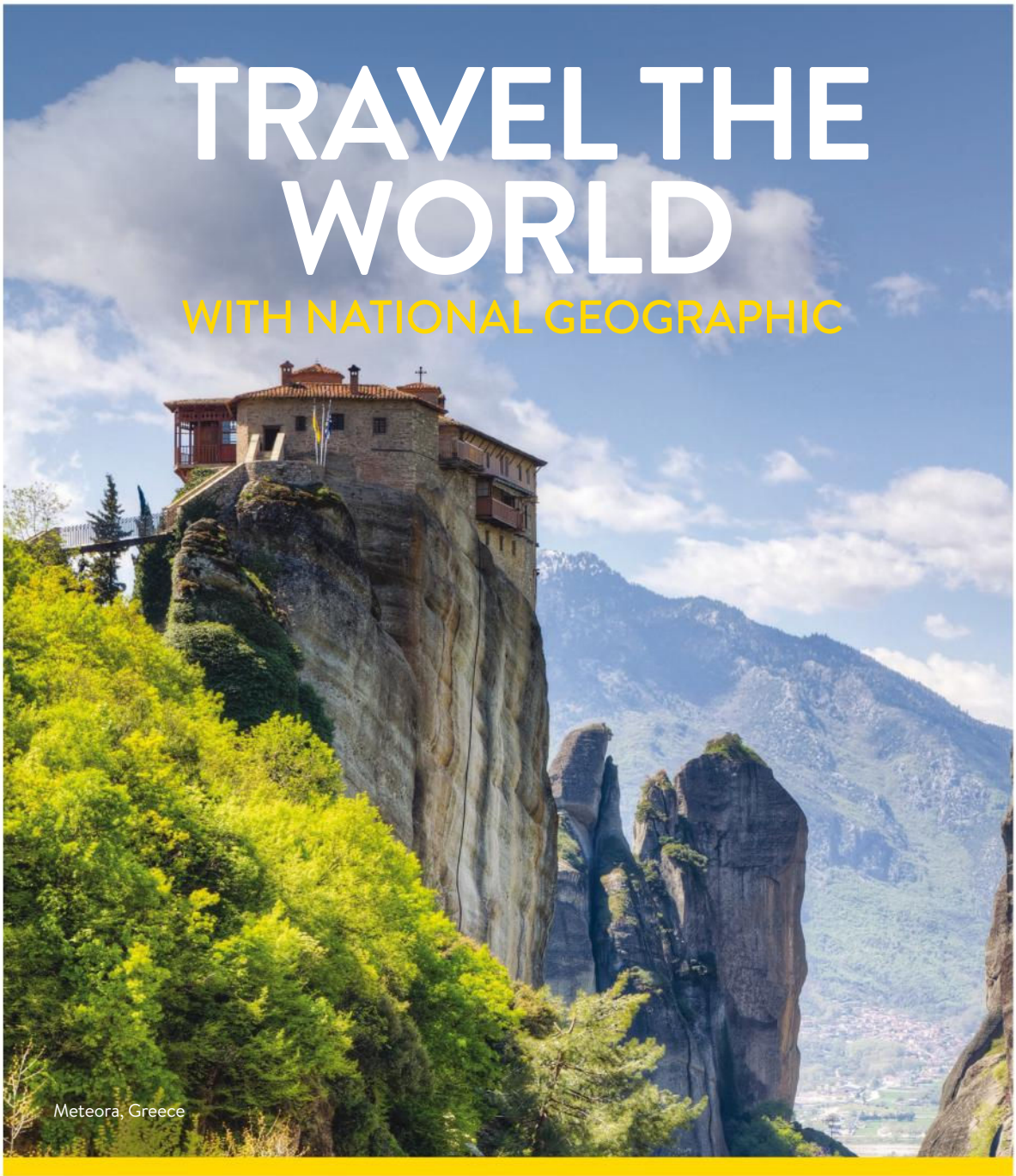

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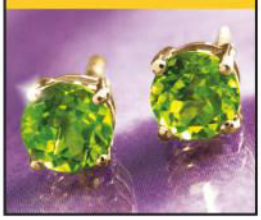

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Falling for Each Other

Bald eagles, aka *Haliaeetus leucocephalus,* seem to be models of decorum. The raptors mate for life, unless one partner dies early. Year after year most return to the same nests. Birds in some so-called monogamous species still mate with other partners; bald eagles seem not to.

But when it comes to courtship, bald eagles put the wild in wildlife.

The maneuver above—known as the cartwheel display or death spiral—is chief among their "spectacular courtship rituals," says wildlife ecologist David Buehler of the University of Tennessee. "The two soar up to high altitude, lock talons, and tumble and cartwheel toward Earth." They let go before reaching the ground—except when they don't. In 2014 two adult eagles, talons locked, were found tangled in a Portland, Oregon, tree. (They eventually broke free and flew off.)

The courtship display is about "determining the fitness of your mate" and making that mate want to mate with you, Buehler says. "It's like going out on the dance floor if you're a really good dancer." There are risks: The stunt could, for instance, end in a fatal crash. "It's an interesting tension," he says, "between succeeding with a mate and maintaining your own survival." *—Patricia Edmonds*

HABITAT/RANGE
Forests near waterways in North America

CONSERVATION STATUS
After decades of Endangered Species Act protections and a ban on the pesticide DDT, bald eagles rebounded and are ranked "least concern."

The courtship ritual involves locking talons and tumbling toward Earth.

PHOTO: HARRY EGGENS

The more
science there is
in forensic science,
the more justice
is served.

BEYOND REASONABLE DOUBT

This FBI analyst brings 20 years of experience to his comparison of bullet casings. His opinion is expert. But is it science?

TYPE DESIGN BY CRAIG WARD

A roadside memorial marks where Sierra Bouzigard's body was found seven years ago in Calcasieu Parish, Louisiana. There were no witnesses to the murder, and the DNA under her fingernails matched none of the suspects. Yet Detective Les Blanchard—here revisiting the scene—is hopeful a new forensic technique might help solve this cold case.

By Veronique Greenwood
Photographs by Max Aguilera-Hellweg

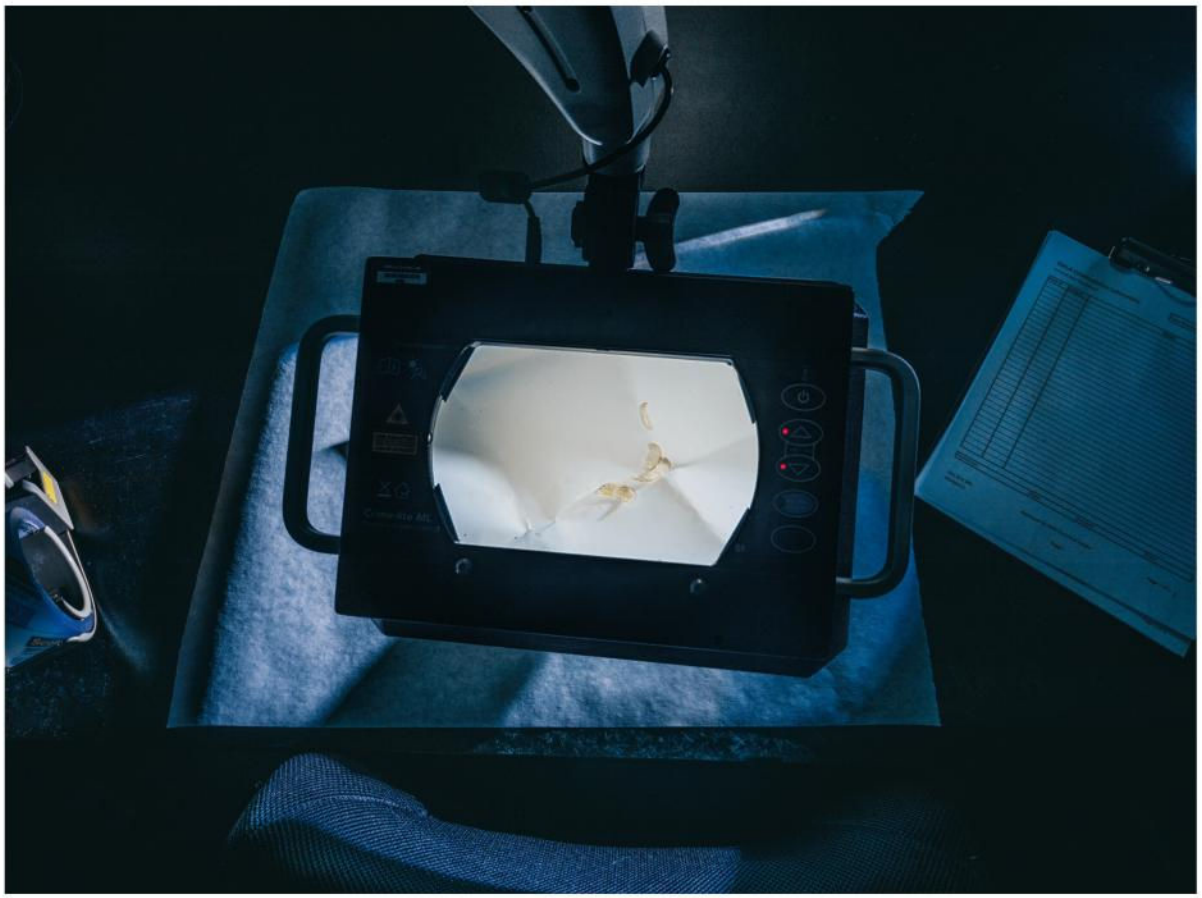
On the morning of November 23, 2009,

a cyclist riding near Lake Charles, Louisiana, discovered the body of a young woman lying near a country road. Her face had been beaten beyond recognition, but an unusual tattoo led the police to identify her as 19-year-old Sierra Bouzigard. Investigators from the Calcasieu Parish Sheriff's Office, headed by Sheriff Tony Mancuso, immediately set about reconstructing her final hours. The people who last saw Bouzigard alive had let her use their phone. The number she dialed gave police a lead.

Bouzigard's assailant had also left behind a promising clue. From tissue caught under her fingernails as she struggled for her life, the detectives were able to pick up a clear DNA sample. To find the killer, all they needed was a match. The number she had dialed led police to a crew of undocumented Mexican workers. "So we started getting warrants for DNA swabs, getting translators, working with immigration," Mancuso recalls.

But none of the Mexicans' DNA matched the sample from the crime scene. Nor was there a hit in the FBI's database of prior felons, missing persons, and arrestees, a system known as CODIS—the Combined DNA Index System. The investigators continued to issue calls for people with any information to come forward, and Bouzigard's family offered a $10,000 reward. But the case grew cold.

Then, in June 2015, Monica Quaal, a lead DNA analyst at the lab that works with the sheriff's office, learned about an intriguing new way of exploiting the information contained in a DNA sample—one that would not require a suspect's DNA or a match in a database. Called DNA phenotyping, the technique conjures up a physical likeness of the person who left the sample behind, including traits such as



Fingernails can catch a murderer. Medical examiners clip a victim's nails to see if DNA from tissue trapped under them during an attack matches a sample in the DNA database. Even without a match, a new technique known as DNA phenotyping can reveal the assailant's eye, skin, and hair color—or even suggest the outlines of a face.

geographic ancestry, eye and natural hair color, and even a possible shape for facial features. Quaal immediately thought of the Bouzigard case, in which the DNA left at the scene was virtually the only lead. She contacted Mancuso and Lt. Les Blanchard, a detective on the case, and they sent their sample to Ellen Greytak, director of bioinformatics at Parabon NanoLabs, a company specializing in DNA phenotyping.

Here the investigation took an unexpected turn. Based on the available evidence, the detectives still believed her killer was likely Hispanic—perhaps a member of the Mexican crew who had fled the area soon after committing the crime. But the person in the DNA-generated portrait Parabon produced had pale skin and freckles. His hair was brown, and his eyes were probably green or blue. His ancestry, the analysis said, was northern European.

"We kind of had to take a step back and say all this time, we're not even in the right direction," Mancuso says. But armed with this new evidence, he is optimistic. "I think at some point we can solve this case, because we have such a good DNA sample and this profile," he says. "We know who the killer is. We just don't know *who* the killer is."

DNA phenotyping is a relatively recent arrival

The skull of a murdered man offered few clues to his identity when it was found in a trash can in Glen Burnie, Maryland, in 1985. But Parabon NanoLabs was able to re-create the victim's face by using DNA phenotyping combined with key details from the skull. Police hope that someone will recognize the composite image and call 410-222-4700.

Many forensic methods offer far less certitude than TV dramas would suggest. And when forensic evidence is oversold in court, innocent people go to jail, or worse.

in forensic science, and some critics question how useful it will be. The facial composites it produces are predictions from genetics, not photographs. Many aspects of a person's appearance are not encoded in DNA and thus can never be unearthed from it, like whether someone has a beard, or dyed hair. Nevertheless, Parabon, which calls its facial composite service Snapshot, has had more than 40 law enforcement organizations as customers. Human genome pioneer Craig Venter, as part of his new personalized health company called Human Longevity, is also investigating facial reconstruction from DNA, as are many academic labs.

Meanwhile other high-tech forensic methods are coming on the scene. CT scanners allow doctors to perform virtual autopsies, peering into bodies for signs of murder undetected by standard autopsies. Researchers are studying whether bacteria on corpses can provide a more accurate clock to gauge when death occurred. And they're even investigating whether culprits might be identified not just by the DNA left at a crime scene but also by the microbial signature of the bacteria they leave behind.

The forensic techniques we're more familiar with from movies and television shows such as *CSI* have far longer histories. In 1910 Thomas Jennings became the first American convicted of murder based primarily on fingerprint evidence. He was accused of shooting one Clarence Hiller during a bungled burglary. The culprit had left his fingerprints behind on a freshly painted windowsill, and the testimony of four fingerprint experts was nearly the entire basis on which Jennings was found guilty and sentenced to death. In response to his appeal, a higher court pointed both to the long heritage of using fingerprints for identification—pharaohs employed thumbprints as signatures, they said—and to "the great success of the system in England, where it has been used since 1891 in thousands of cases without error." The court did caution that because such evidence fell beyond the purview of the average person's experience, it must be presented by experts who could explain it to the jury. The verdict was upheld, and Jennings was hanged.

By the late 20th century, there were numerous investigative techniques in the courtroom. FBI analysts gave testimony comparing hairs found at a crime scene with those from suspects. Hair-analysis experts note the shape of the microscopic scales that coat hairs, the thickness and coloration of the hair, and the organization of pigment granules in it, among other qualities. Bite-mark analysis, in which experts compare the pattern left by a bite on a victim to a suspect's teeth, was widely adopted in the early 1970s, including a 1974 court case that hinged on marks identified on a dead woman's nose after she'd been exhumed. Other visual comparisons—between tire tracks, shoe prints, and patterns on bullet casings—also made their way from being clues used by law enforcement to identify suspects to becoming evidence presented in court to help prove guilt. In thousands of cases, judges tasked with deciding whether evidence is reliable have leaned on ample precedent to allow such forensic results to be admitted in court. Experts with years of experience at their craft have testified with assurance.

But over the past decade or so, it's become apparent that many forensic methodologies offer far less certitude than TV dramas suggest. And when forensic evidence is oversold in court, innocent people go to jail, or worse.

■ **Grant** Your National Geographic Society membership helped fund DNA-phenotyping research.

IN 1981 A WOMAN in Washington, D.C., was attacked in her apartment—gagged, blindfolded, and raped. She worked with a police artist to create a composite of her attacker, and about a month later an officer tipped off detectives to 18-year-old Kirk Odom, who he believed resembled the sketch. Odom's mother testified that he'd been at home; she remembered the day because his sister had just had a baby. The victim uncertainly picked a picture of Odom out of a photo lineup, then positively identified him in a live version. An FBI analyst's subsequent testimony that Odom's hair was microscopically indistinguishable from a single hair found on the victim's nightgown helped clinch the case against him. He spent more than 22 years in prison and eight on parole as a sex offender before D.C.'s Public Defender Service pursued new evidence that proved him innocent.

In 1992 Cameron Todd Willingham was accused of setting the fire in his house in Corsicana, Texas, that killed his three young daughters. Fire investigators interpreted charred patterns on the home's floor and what appeared to be multiple places where the fire started as signs of an intentional, gasoline-lit blaze. In 2011 the state of Texas found that the interpretation of evidence in the case had been fatally flawed. But it was too late for Willingham: He had been executed seven years earlier.

And then there's Oregon attorney Brandon Mayfield, who was arrested by the FBI at his law office in May 2004. Mayfield remembers an agent shouting obscenities at him during the arrest. The agents didn't clarify the reason behind the arrest; to find out, he had to read the warrant with his hands cuffed behind him. His fingerprints had turned up in a search of the Integrated Automated Fingerprint Identification System, and were determined by two FBI fingerprint examiners to be a match to those found on a plastic bag containing materials used in the terrorist bombings in Madrid, which had killed 191 people. The Spanish authorities, however, didn't agree. Two weeks after Mayfield's arrest, they sent word that they had found their own match to the prints—an Algerian man, still at large, now regarded as one of the key planners of the attacks.

What all these stories have in common is their reliance on methods and interpretations that involve more craft than science. The power of hair analysis, for instance, has been vastly overstated. The FBI admits that its analysts have made erroneous statements in more than 90 percent of the microscopic-hair-comparison cases it has reviewed.

Arson evidence is also being challenged. For many years, arson investigators examined patterns on windows where a fire occurred to see if they were cracked—or "crazed"—in a characteristic way. They looked for whether a metal doorsill had melted, or a concrete floor had burst under the heat, a phenomenon called spalling. If temperatures were high enough to cause such damage, it was regarded as evidence that a substance such as gasoline was used to start the blaze. But fire investigator John Lentini, who co-authored a report to the Texas Forensic Science Commission about the Willingham case, says that such assumptions are outdated.

"The theory was that after a short time, a fire started with gasoline is throwing off much more heat than a fire burning wood only," Lentini says. "Therefore, the flame temperature must be higher, right? Wrong!" Research shows that ventilation, much more than what started the fire, is what determines the heat and speed of a blaze. Crazed glass, spalled concrete, melted metal—in tests with burning rooms, all can happen in the absence of gasoline, if the ventilation and other factors are right.

Even the reliability of fingerprint evidence has been called into question. While computers do a good job of matching a set of standard ink-recorded or electronically scanned fingerprints through a database search, they're still not as good as the human eye when it comes to matching latent fingerprints with those of a suspect. And because latent prints often are distorted or smudged, matches rely on the judgment of experts who, however skilled, are providing a subjective opinion. One study found that examiners sometimes came to different

Kirk Odom was convicted of rape after an expert testified that a hair on the victim's nightgown matched his. Odom spent more than 22 years in prison and eight on parole before DNA tests proved his innocence and fingered the real culprit. The FBI is now reviewing hundreds of other cases where the value of hair analysis may have been overstated.

The Trouble With Teeth

A forensic dentist testified that the chances were one in a million that a bite mark on a murder victim's arm came from anyone but Steven Mark Chaney (above, on his bed), who was convicted of the crime in 1987. But there is little science to back up bite marks' validity as a forensic tool. In one study 30 dentists analyzed bite marks created by a Bite-o-matic on pigskin as a stand-in for human flesh (left). Even experienced examiners made errors. Chaney was set free last October after the bite-mark testimony was dismissed.

PHOTOGRAPHED AT ONTARIO FORENSIC PATHOLOGY SERVICE (LEFT)

Not coincidentally, the one forensic method that passed scrutiny was developed not by law enforcement to aid investigation of crimes but by a scientist working in an academic laboratory.

conclusions about the same fingerprint if they were told the print had come from a suspect who had confessed to the crime or was in custody. In the case of Brandon Mayfield, a federal report revealed that the analysts had convinced themselves of similarities that didn't exist.

In 2009 the National Academy of Sciences released a blistering report calling into question the scientific validity of the analysis of fingerprints, bite marks, blood spatters, clothing fiber, handwriting, bullet markings, and many other mainstays of forensic investigation. It concluded that with one exception, no forensic method could be relied on with a high degree of certainty to "demonstrate a connection between evidence and a specific individual or source."

Not coincidentally, the one forensic methodology that passed scrutiny in the NAS report was developed not by law enforcement to aid the investigation of crimes but by a scientist working in an academic laboratory. In 1984 British geneticist Alec Jeffreys stumbled upon a surprising truth: He could tell people in his experiment apart solely by patterns in each person's minced-up DNA, the genetic code we all inherit from our parents.

Jeffreys's discovery formed the basis of the first generation of DNA tests. Three years later Jeffreys's lab processed DNA from a 17-year-old suspect in the rape and murder of two teenage girls in central England, and saw that it did not match DNA from semen found in the victims. Thus the first use of DNA in a criminal case led not to a conviction but to an exoneration. (The true killer later confessed, after he tried to elude DNA screening of a group of men in the area.)

Soon other, more sensitive tests were in use, and by 1997 the FBI was employing one that looked at 13 places on the genome where stutters in the DNA code cropped up. The odds of any two unrelated people having the same 13 patterns were one in at least hundreds of billions. It was these patterns that wound up forming the basis of the FBI's CODIS database. By the 1990s, DNA profiling was being widely used in court cases around the world—in the United States, most famously in the murder trial of O. J. Simpson.

DNA evidence is hardly incontrovertible. Its value can be compromised by contamination from extraneous DNA anywhere along the chain from the crime scene to the laboratory where the sample is sequenced. A robust signal from semen, saliva, or tissue can narrow the probability of a false match to virtually zero, but trace amounts of DNA left on an object handled by a suspect can yield much less accurate results. And a DNA sequence in a lab is only as good as the training of the person conducting the analysis. In April 2015 DNA analysis in the D.C. crime lab was suspended for 10 months and more than a hundred of its cases were reviewed, after an accreditation board found that analysts there were "not competent" and were using "inadequate procedures."

IT'S BEEN SEVEN YEARS since the National Academy of Sciences report called for a complete overhaul of forensic science. Some of its recommendations—to create a National Institute of Forensic Sciences, for example—are unlikely to come to pass for financial reasons, say government sources. Others, like an increase in research to establish how reliable fingerprints, bite marks, and other patterns really are at identifying individuals, are under way. In the first five years after the NAS report, the National Institute of Justice spent $100 million on projects that have resulted in more than 600 scientific studies and reports. But the going is slow.

"There are the rudiments of some important,

beginning changes," says Jennifer Mnookin, dean of the UCLA law school, "in fingerprint evidence in particular." In 2012 the federal government released new guidelines for a fingerprint-analysis work flow aimed at preventing opportunities for error. And some fingerprint experts say that they're in the midst of a paradigm shift, away from the long-standing professional protocol that required fingerprint analysts to present their courtroom opinions with absolute certainty. Instead these experts now argue that they should express their findings in probabilities, as DNA experts do.

Cedric Neumann, a professor of statistics at South Dakota State University who specializes in fingerprints, is one of those arguing for a better way for analysts to express the uncertainty in their results. Neumann and others also hope to develop a more objective way to look at the loops, arches, and whorls used to compare fingerprints.

The development of such standards is key to making forensic science, well, scientific. The National Institute of Standards and Technology (NIST) is helping to hammer out a list of best practices for how to calibrate instruments, what processes to use when comparing fingerprints, and how to interpret bullet casings and DNA typing and drug analysis results, along with many others. "Eventually there will be this registry of standards, which says this is the level at which the bar is set," says John Butler, an analytical chemist who is special assistant to the director for forensic science at NIST. "Right now there's nothing there."

Even once the bar is set, NIST cannot require facilities to meet its guidelines. What will likely happen is that facilities that can show they meet the standards for a procedure will be eligible for accreditation—an optional certification process offered by a third party. Currently more than 80 percent of forensic labs have general accreditation, indicating that they've fulfilled basic requirements for best practices. But plenty of forensic work takes place outside of labs, in forensic units of police departments. When a 2014 survey looked at more than a thousand forensics providers, including both labs and police departments, the authors found that upwards of 70 percent didn't have a general accreditation.

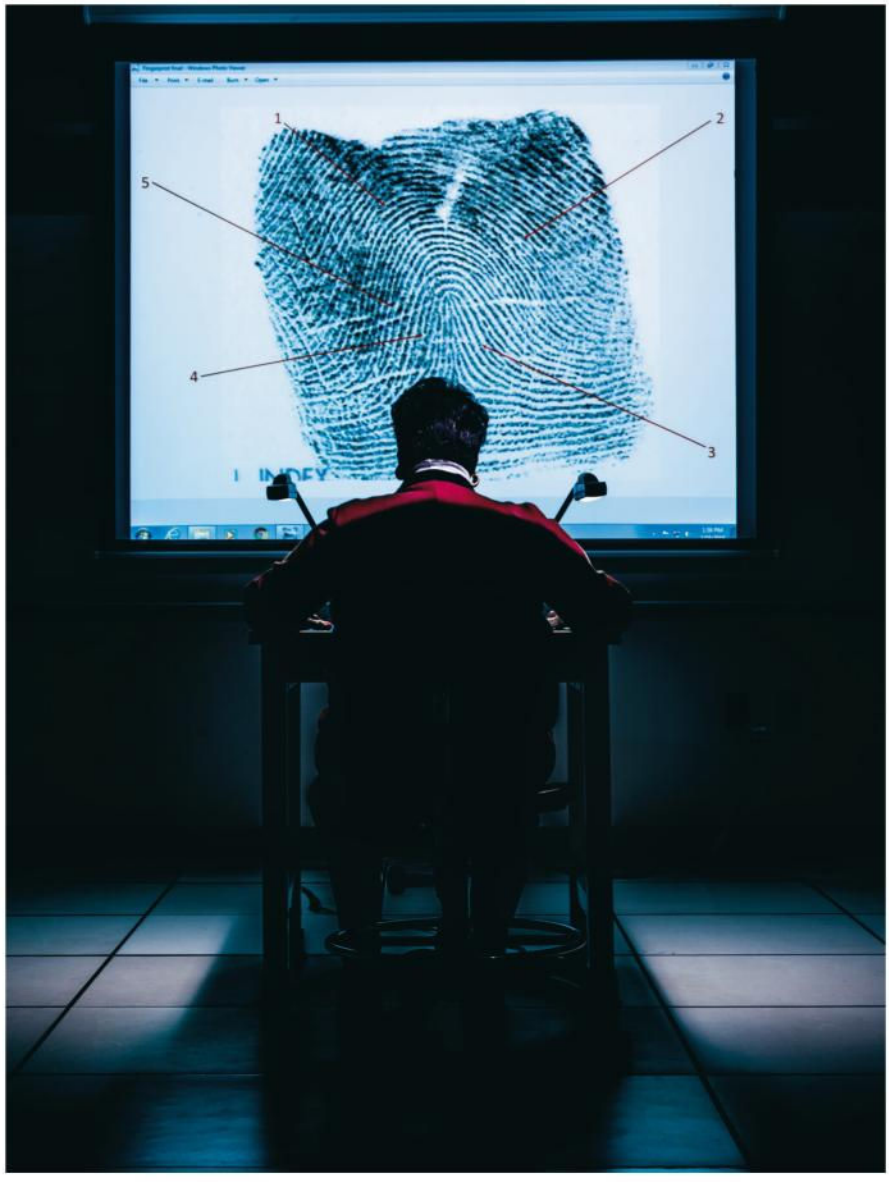
Another impediment, says Mnookin, is that judges, who are the gatekeepers of the courts, continue to admit questionable forensic evidence—including hair and bite-mark analysis. As long as such testimony continues to be admitted in court, there's little incentive for forensics experts to make substantive changes. "Judges haven't actually taken seriously the need to establish validity, to have a known error rate," Mnookin says. "The judiciary has largely punted on this."

But while the pace of change is slow, there are some hopeful signs. In February of this year, the Texas Forensic Science Commission became the first in the country to recommend a moratorium on the use of bite marks as evidence in court until their validity could be studied and confirmed. The decision was prompted in part by the release the previous fall of Steven Mark Chaney, a Texas man who had served 28 years in prison after a murder conviction that hung largely on bite-mark evidence that has since been dismissed as scientifically unsound.

WITH TRADITIONAL FORENSIC techniques facing such scrutiny, does a new science-based one such as DNA phenotyping offer more hope, or another source of uncertainty?

On September 1, 2015, the Calcasieu Parish Sheriff's Office in Lake Charles, Louisiana, released to the media a likeness of the white male suspected in the killing of Sierra Bouzigard. The image produced by Parabon NanoLabs (see page 51) expresses both how much of a person's appearance can be coaxed from DNA and how much cannot. The face is eerily devoid of personality or affect. Nothing lurking in the eyes suggests a troubled childhood; there's no sneer on the full lips that might betray a penchant for evil or contempt for the law. It could be your second cousin, or the guy who served you at the deli yesterday, or the fellow you have a crush on in your graduate economics seminar. Or it could be the man who in 2009 battered a young woman to death. *(Continued on page 54)*

At a “body farm” at Sam Houston State University, in Huntsville, Texas, forensic entomologist Sibyl Bucheli studies the number and type of insects swarming a decaying body, to determine the time of death. Now scientists are investigating how changes in bacteria that decompose a cadaver could provide more precise clues about when a person died.



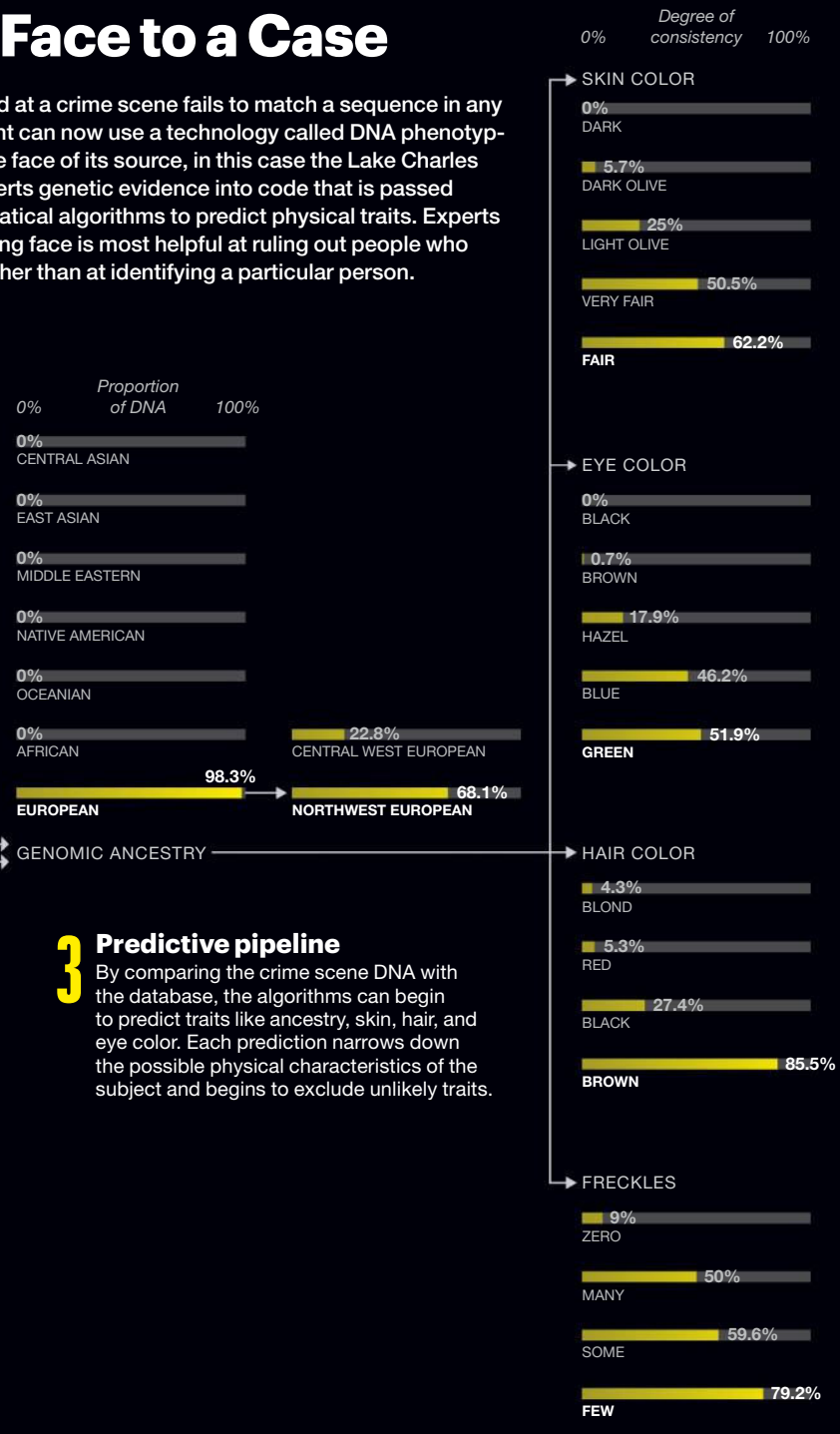
Forensic Science, Now With More Science

Since a 2009 report by the National Academy of Sciences criticized arson investigation and fingerprint analysis as more craft than science, both fields have upped their game. Left, an arson lab burns a bedroom to collect data on heat, smoke, and gases released by the fire. And new protocols for fingerprint identification are in place. Above, Sylvia Buffington-Lester, a fingerprint expert for 45 years, says analysts must study prints from a crime before viewing a suspect's print: "If you start with the perfect print, you're biased."

PHOTOGRAPHED AT ATF FIRE RESEARCH LABORATORY (LEFT)

Putting a Face to a Case

When a DNA sample found at a crime scene fails to match a sequence in any database, law enforcement can now use a technology called DNA phenotyping to reverse engineer the face of its source, in this case the Lake Charles killer. The technique converts genetic evidence into code that is passed through complex mathematical algorithms to predict physical traits. Experts emphasize that the resulting face is most helpful at ruling out people who don't match the profile rather than at identifying a particular person.



1 The evidence

Forensic specialists collect biological evidence from the crime scene and send it to a DNA lab, where about a million genetic markers are scanned.

2 The database

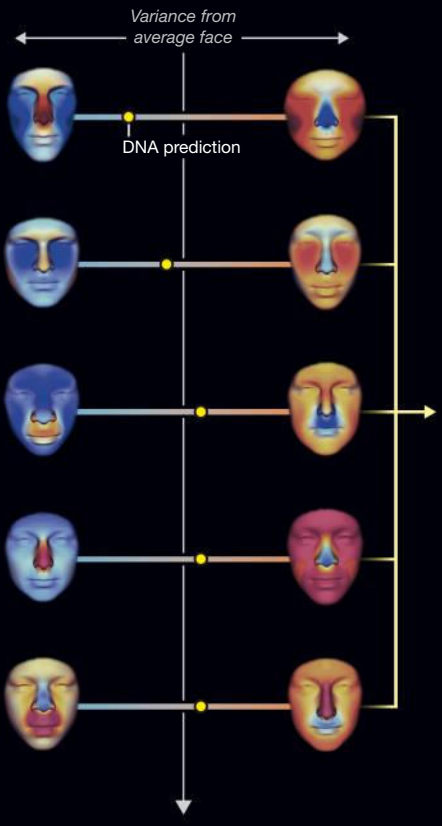
A database containing 3-D facial scans and DNA for thousands of people is used to generate sophisticated algorithms matching DNA with physical traits.

3 Predictive pipeline

By comparing the crime scene DNA with the database, the algorithms can begin to predict traits like ancestry, skin, hair, and eye color. Each prediction narrows down the possible physical characteristics of the subject and begins to exclude unlikely traits.

JASON TREAT AND RYAN WILLIAMS, NGM STAFF

SOURCES: THOM SHAW (FORENSIC ART) AND STEVEN ARMENTROUT, PARABON NANOLABS, INC.



4 Predicting features

Algorithms use sex, ancestry, and thousands of genetic markers to predict how a subject's facial measurements, such as skull width and lip size, fall along spectra of facial variation.

5 3-D identification

The final face takes into account all the available genetic information for facial structure, geographic ancestry, and eye, skin, and hair color. The image above is what computer algorithms predict the Lake Charles suspect looked like at age 25.

RANGE OF OPTIONS

The model can be altered by a forensic artist to reflect possible ages and weights, as well as superficial features including hairstyles or dyed hair. At right are three variations.

Graduate students at Virginia Commonwealth University, in Richmond, investigate a mock crime scene in a motel room to learn to document evidence in exquisite detail. The NAS report called for more training tied to academic institutions as a way to bolster the profession's credibility.


3

The Bouzigard case is not the first time DNA phenotyping has come to the aid of a criminal investigation. A cruder form of the technology, using DNA to identify only the geographic ancestry of a suspect, was instrumental in catching a serial killer in Louisiana in 2003. Much as in the Bouzigard case, the police had been looking for someone of a particular ancestry, and the DNA profile indicated they were looking at the wrong segment of the population.

Newer versions of the technique flesh out the ancestral profiles with physical traits that have known genetic roots. Both East Asians and Europeans have pale skin—but because of different underlying genetic influences. Pale skin in Europeans is linked to a particular version of a gene called *SLC24A5*. Almost all Europeans have two copies of that version of the gene; non-European people with one copy of the version have much lighter skin than those with none at all. "I can probably sit down with a room of African Americans and tell you who has that gene with pretty good accuracy," says Mark Shriver, a professor of biological anthropology at Pennsylvania State University. "It has that strong of an effect."

In addition to tracking versions of genes known to code for certain traits, creators of a DNA phenotype can look for tiny variations, called single nucleotide polymorphisms (SNPs), sprinkled throughout the genome. They're known to be associated with physical features, such as hair and eye color, a tendency to freckle, and whether the earlobes of the individual are attached or unattached.

Researchers at Parabon and Venter's Human Longevity go a step further and use huge computer databases to seek out connections between a pattern of SNPs and the shape of a person's facial features. Volunteers are asked to fill out questionnaires about their appearance, including details such as whether they have freckles. A sample of each volunteer's DNA is then checked at about a million points where SNPs are known to occur. A 3-D scanner records the shape of the volunteer's face—the particular angles of cheekbones, jawline, nose, and so on—to create a computerized image of the face. Computer algorithms can then look for associations between particular patterns of SNPs with salient features in the 3-D scans of the same individual, such as jawline or nose shape—a massive data crunch that can take weeks, running on hundreds of computers. The resulting correlations between SNP patterns and known features can then be used to reverse engineer a face from a sample of DNA from an unknown individual—such as the killer whose tissue was found under Bouzigard's fingernails.

The question, of course, is how closely that face resembles the person who contributed the DNA from which it was derived, to the exclusion of other people, even ones with similar geographic ancestry. Theoretically, the more people of different ethnicities and facial profiles contribute to the DNA database, the better it will become at predicting the faces of crime suspects. What's missing so far, says Manfred Kayser, a professor at Erasmus University Rotterdam who has developed a test that predicts eye and hair color from DNA, is clear, published proof that models built from a database of even many thousands of people can generate an accurate picture of someone from outside the database. "The key thing is that whatever they are doing, it has to be validated, it has to be replicated," he says. Parabon is currently working on a small test of its methodology with Bruce Budowle, head of the University of North Texas Institute of Applied Genetics and a former DNA expert for the FBI.

PARABON NANOLABS

Max Aguilera-Hellweg is a photographer, filmmaker, and physician—though he doesn't practice medicine. To see if you can identify Max from this image derived from his DNA, go to *ngm.com/Jul2016*.

What's it like working at a crime scene?
I shot at the site where Sierra Bouzigard was murdered. It was calm and peaceful, and a deep sense of respect overtook me for the person who died there. I wanted the picture I took to help tell her story. Maybe it could even help catch her killer.

On a mock residential street at an FBI training facility, a forensics investigator learns how to use lasers to help visualize the flight path of bullets and reconstruct shooting incidents. Both rigorous training and scientifically proven methods are essential, critics say, to setting forensic science on the right trajectory.

Steven Armentrout, Parabon's CEO, says it's important to be clear about how the company's facial reconstructions should best be used: not to identify a particular suspect but to eliminate ones who clearly don't resemble the image, beginning with people who obviously don't match—such as the Mexican laborers in the Bouzigard case.

"In the future," says Armentrout, "we would be doing this at the beginning of the investigation—who should and shouldn't be on your suspect list." As the field of inquiry narrows, the DNA of a suspect not excluded by the Parabon Snapshot could be tested against the actual sample left at the crime scene. And Parabon's phenotyping is not intended to identify specific individuals.

"I would underscore that message," Armentrout says. "These new technologies are really just making the process of law enforcement more efficient."

Les Blanchard, the detective in Lake Charles who hopes to solve the killing of Sierra Bouzigard, says he and his team have received multiple tips since releasing the Parabon Snapshot to the public last September. They've started knocking on doors.

As of this writing, no matches yet. □

Park rangers undergo military-style training, including ambush tactics. Since the ethnic conflict in neighboring Rwanda spilled into Congo in 1994, rangers have faced a constant threat from various armed groups.

The Battle for VIRUNGA

Saving one of the world's most dangerous parks

A silverback from the 22-member Mapuwa family emerges from the jungle to keep an eye on a ranger patrol. The park has largely succeeded in protecting mountain gorillas, its top tourist draw, from violence. Their population is now growing.

By Robert Draper
Photographs by Brent Stirton

Emmanuel de Merode, flanked by bodyguards at park headquarters nine months after he survived an assassination attempt, has led the park for eight years. He has become the public face of the conservation effort in war-torn eastern Congo and a target for the park's opponents.

When the ranger studied the ragtag crew he was supervising, seven young men repairing a rugged road that leads to Virunga National Park, it did not take much to see what he had in common with them. They were all born and raised in or around the park on the eastern edge of the Democratic Republic of the Congo. None of them were rich. None of them would ever be rich. All of them had seen loved ones fall by the capricious machete stroke of a war with murky logic and no foreseeable end.

And now here they all were, working for the park, filling potholes and clearing drainage ditches in the furtherance of something considerably more profound than nine miles of rough gravel. The road joins the Bukima ranger post with tourists from the West, whose money helps support Africa's oldest national park. These visitors come here principally to fulfill a dream—namely, to stand mere feet away from the park's illustrious residents, the rare mountain gorillas.

Less famous but just as important, the Bukima road connects farmers outside the park with village markets and the city of Goma beyond. For years it had been a morass of large rocks and quicksand-like mud. Its impassability made hard lives that much harder. But now the park was pouring money into the road's reconstruction. And local men like these were repairing it. So the road also constituted a bond, albeit a slender one, between the region's most visible national institution and villagers who view the park with hostility and, at times, rage, believing the land should still belong to them.

Here was where the ranger, a captain named Theo Kambale, parted ways with the young men. Kambale's heart held nothing but reverence for the park. You could see it in the crispness of his uniform, the care with which he tucked his green pants into his boots, which he fastidiously polished. Kambale was 55 and had spent 31 of those years as a ranger. His father, also a ranger, had died in 1960, the year of Kambale's birth, gored by an African buffalo. His older brother had also been a ranger. He too had been slain in the line of duty, in 2006. The killer was not a wild animal, but instead a member of one of many armed

groups that have ravaged and occupied Virunga for two decades.

To these young men raised in poverty, that Virunga's tremendously fertile soil, its trees, and its creatures should be protected by law for the viewing pleasure of well-off tourists struck them as a grave injustice. They were swept into a militia known as M23, which touted a host of grievances against the corrupt government but in the meantime was content to loot and rape its way through a slice of eastern Congo near the park's southern sector. By the end of 2013, after more than a year and a half of fighting, the Congolese Army, backed by United Nations troops, routed M23. Among the militia's foot soldiers deemed salvageable, by UN peacekeepers and park officials, were these seven.

The work on the Bukima road was harder and less profitable than looting. But the former rebels kept at it. Kambale was impressed. He talked to them from time to time. "Before now, all you were creating was insecurity in the region," he would say. "Now you're building this road. It's a start. From here you can go on to do other things. But you can't progress if there's no security. So tell that to your friends. Tell them to leave their armed groups. Because that is not life. This"—and he would gesture toward the road—"is the beginning of life."

EXPLORER

Tune in at 8 p.m. on Sunday, June 26, to National Geographic Channel's Explorer series episode *Battle for Virunga.*

The road constituted a bond, albeit a slender one, between the park and villagers who view the park with hostility, believing the land should belong to them.

The ranger hoped that his message would sink in. He knew of their desperate backgrounds. He was aware that most had been conscripted by force. Across their arms and backs was a grisly network of scars, testifying to their semi-enslavement. Seeing these men in their 20s permanently marked by brutality, Kambale thought of his own injury, delivered by a militia spear to his right leg. Proof of residency, you could say. If they could look past their battle wounds, perhaps this park could be saved.

THERE IS NO NATIONALLY PROTECTED AREA in the world quite like Virunga, in ways both blessed and cursed. Its approximately two million acres include a web of glacier-fed rivers, one of Africa's Great Lakes, sun-bleached savannas, impenetrable lowland rain forests, one of the highest peaks on the continent, and two of its most active volcanoes. Virunga hosts more than 700 bird species (among them the handsome francolin and Grauer's swamp warbler) as well as more than 200 mammals (including the odd-looking okapi, with zebra-striped hind legs, and 480 of the world's 880 remaining mountain gorillas). Standing where the Semliki River flows out of Lake Edward with the Rwenzori Mountains glowering in the distance, serenaded by a moaning Greek chorus of water-besotted hippos, and gazing down at a thoroughly uncontaminated tableau of swimming elephants and strutting saddle-billed storks backlit by a low morning sun, one becomes very small, very silent, and very aware that nature's brave feint of indomitability has all but come to an end.

For Virunga has been, going on two decades, a war zone. In 1994 the horrific ethnic conflict in neighboring Rwanda that led to the genocide of Tutsis by Hutus spilled across the border into Congo. Hutu fighters and more than a million refugees fled Rwanda after their defeat, settling in nightmarishly overcrowded camps around the park. Some Hutus later formed the Democratic Forces for the Liberation of Rwanda—known by its French acronym, FDLR—the militia that killed Kambale's older brother. Congolese Tutsis eventually responded with the National Congress for the People's Defense, or CNDP, which then spawned the March 23 movement, or M23. One bloody iteration after the next—fomented by these armed groups—has plowed into the park like a threshing machine.

Many of the fighters, along with Congolese Army soldiers purporting to defend the territory, lingered well after the cease-fires, expunging the park's wildlife for personal consumption or for sale as bush meat. Thousands remain in the jungle to this day, and thousands more from a shifting array of locally formed militias called Mai-Mai have joined them. Attempts by rangers to drive them out have led to deadly reprisals. This past March two rangers were executed in Virunga's central sector, driving up the death toll of park rangers to 152 since 1996.

A different kind of war also looms over Virunga. This one pits the park and its ecological well-being against the search for oil. London-based Soco International obtained a concession in 2010 that allowed it to explore about half of Virunga, including the area near Lake Edward. After a sustained outcry led by conservation groups, four years later Soco backed down and now says it no longer holds the concession. The Ugandan government, however, has shown an interest in exploring for oil on its side of the lake, a grim reminder that the park and its precious resources are anything but sacrosanct.

The park is also a volatile staging ground for Congo's internal grievances. As it happens, Virunga's terrain is among *(Continued on page 70)*

Park Politics

Conservationists and tourists value Virunga National Park for its spectacular terrain and biodiversity. But some who live in extreme poverty near the park's two million acres resent that they are not allowed to make use of its natural resources.

ILLEGAL INDUSTRY
Rangers wage a constant battle to prevent the farming, poaching, mining, and charcoal making that devastate the park.

OIL EXPLORATION
For now, efforts to search for fossil fuels in the park have been derailed by intense opposition, but Uganda is still weighing oil exploration on its side of Lake Edward.

NEW JOBS
Hydroelectric projects such as the Mutwanga and Matebe Dams provide power and economic alternatives to the illegal activities that sustain armed groups.

POPULATION PRESSURE
Ongoing regional conflict has displaced people throughout the area, making them more likely to forage for food and wood inside the park.

Level of violence 2010-2015
Low — High
Deforestation 2010-2015
Armed group influence, 2015
Volcano
0 mi 20
0 km 20

Beni
Semliki
Margherita Peak 16,765 ft 5,110 m
Butahu
Mutwanga
MUTWANGA DAM
RWENZORI MTS.
Butembo
VIRUNGA
Biena
Lubero
DEMOCRATIC REPUBLIC OF THE CONGO
Kazinga Channel
UGANDA
Lake Edward
N2
Lulimbi
Nzungu
MOUNTAINS
NATIONAL
Vitshumbi
Rwindi
Rutshuru
Ishasha
Rwindi Hotel
Rwindi Station
Luhulu
Kitshanga
Rutshuru
MATEBE DAM
Rumangabo Station (Park Headquarters)
BUKIMA ROAD
Bukima Station
PARK
Nyamulagira
Rugari
Sabinyo
VIRUNGA MOUNTAINS
Mikeno
Visoke
Nyiragongo
Karisimbi
MITUMBA MOUNTAINS
RN4
Tchegera Island
Goma
Lake Kivu
RWANDA

CHARLES PREPPERNAU, NGM STAFF

SOURCES: IUCN AND UNEP-WCMC, 2015 WORLD DATABASE ON PROTECTED AREAS; ESRI; WORLD RESOURCES INSTITUTE AND CENTER FOR GLOBAL DEVELOPMENT; CONGO RESEARCH GROUP, CENTER ON INTERNATIONAL COOPERATION; ARMED CONFLICT LOCATION AND EVENT DATA PROJECT; HOLLY DRANGINIS, ENOUGH PROJECT

Pressing against the park's border, farmers cultivate the exceptionally fertile terrain. With four million people trying to eke out a living in the region, some trespass in the park to grow such crops as corn, sorghum, cassava, and potatoes.

With a bloodhound's assistance, a ranger tries to track poachers who killed this elephant and cut off the front of its head to get away quickly with its ivory tusks. Despite such incidents, the park now has up to 400 elephants, with many crossing the border from Uganda.


R.I.P
MBUSA MATOFALI
Né le 27-07-1988
Déc. le 27.11.2

Rangers carry the coffin of one of their colleagues, Theodore Mbusa Matofali, 27, to a grave in his village. Attending funerals is all too common for the rangers. Since 1996, 152 park rangers have been killed, many by rebel militias operating in the park.

the most fecund in Africa. That it has been set aside for conservation since the park's founding in 1925, thereby depriving one of the world's most deeply impoverished populations of badly needed natural resources, stokes seething discontent among the area's four million inhabitants. Many, in defiance or ignorance of the law, cut down the park's trees for charcoal, plant crops in its forests, kill its wildlife. Some form Mai-Mai militias and take over sections of the bush, emerging in periodic sprees of violence. Others run for elective office essentially as park abolitionists, vowing to reverse the misdeeds of the Belgian colonizers who they say tricked the locals into selling their treasured farmland, or so goes their campaign narrative.

This pervasive climate of resentment is not a small misfortune. Rather, it represents an existential challenge for Virunga. "The truth is that we're not going to succeed unless we mobilize a critical mass of funding," the park's director, Emmanuel de Merode, said, noting that the land, if it were developed, would bring the communities about a billion dollars a year. "Unless we equal that, this park won't survive."

Owing to the region's chronic instability, a mere one-tenth of Virunga is accessible to visitors—and really only half of that could be described as tourist friendly. The park's VIPs—the 250 to 300 mountain gorillas that are habituated to humans—are kept under daily watch by a security team of 80 humans, as would befit a president or a pope. Virunga is national property, but the government in Kinshasa contributes

Bernadette Kahindo (at right) and her oldest daughter, Gift, are among the victims of the fighting. When Kahindo's husband, park ranger Assani Sebuyori Mapine, tried to end the bush-meat trade, a rebel militia killed him in 2011 and left his headless body as a warning to other rangers. The child Gift holds was born after she was raped, at 14, by a fighter from another militia.

only five percent of the park's eight-million-dollar annual operating budget. Most comes from the European Union, the U.S. government, and international nonprofits. Though a first-class hotel, the Mikeno Lodge, opened in 2012 near the gorilla sector, and the sumptuous tent camp on Tchegera Island in Lake Kivu began receiving guests in 2015, the number of visitors has not come close to matching that of the park's prewar heyday. Indeed, the lodge was empty throughout much of 2012 and 2013 as Virunga hosted the latest season of bloodshed, the M23 rebellion.

In the years since, the park has experienced a renaissance thanks to projects, such as the Bukima roadbuilding effort, which aim to show Virunga's neighbors that respect for the park will be rewarded. In particular, de Merode has embarked on an ambitious $166 million hydroelectric scheme utilizing the park's rivers, with the aim of electrifying one-fourth of the area's households by 2020 and creating 60,000 to 100,000 jobs along the way. The outcome, de Merode hopes, will be peace—and with that, more tourism, and thus more income for the region's people, spurring an altogether different cycle from the one that is still bedeviling eastern Congo.

Meanwhile, slowly, the wildlife has begun to rebound. Since the massacre of seven mountain gorillas by charcoal traffickers in 2007, their population has been rising. In the central sector preserve known as Lulimbi, hippos have mounted a surprising recovery, while elephants are wading back across the Ishasha River from the safe haven of Uganda. Aggressive antipoaching operations by rangers have sent an unambiguous message to ivory and bush-meat traffickers: Virunga is no longer an anything-goes playground.

"IT WAS A BEAUTIFUL PLACE," Kambale said one afternoon as he stepped carefully through the weed-choked ruins of the Rwindi Hotel in the central sector. "The hotel was always over capacity. Everyone came to see the wildlife and take pictures. There were so many animals. Even the parking lot was full of antelopes and wild pigs and all types of monkeys."

Today only baboons clamber through the brush. The cylindrical bungalows, the restaurant, the ballroom, the pool where *mzungu* ladies sunned themselves on hot days like this—all vacant and caked with two decades' worth of neglect. The ranger wore a doleful smile, and his eyes were lost in the past. He was born and raised near the Rwindi patrol station. During the year of Kambale's birth, 1960, Congo won its independence from Belgium. Its population, 15 million, was a fifth of what it is now. There was plenty of land to go around, for farmer and animal alike. As a young ranger in the 1980s, Kambale sometimes had to climb a tree to avoid being trampled by a buffalo. When the dictator

A confiscated boat burns on the beach as rangers, joined by an instructor, try to prevent overfishing on Lake Edward. Fishing, a critical source of local income, is allowed on the lake, but rangers are confronted with thousands of unlicensed boats.

Rangers arrest people farming in the park illegally. Farmers are often driven from their homes by fighting and coerced into raising crops to feed armed groups. They may serve time in jail or pay a fine and are educated about how farming harms the park.

BRENT STIRTON, REPORTAGE BY GETTY IMAGES

Owing to the region's chronic instability, a mere one-tenth of Virunga is accessible to visitors—and really only half of that can be called tourist friendly.

Mobutu Sese Seko came to visit—to entertain guests, to plot a course for the country he had renamed Zaire, but most of all to fish on the Rwindi River—it was Kambale's job to hook a live worm onto Mobutu's line. "Mobutu had great respect for the park," said Matthieu Cingoro, a lawyer for the Congolese national park system. "No one could farm in it or cut down trees. No one would even dare trespass."

Then came the refugees from Rwanda. The Rwindi Hotel abruptly locked its doors. The patrol station now saw a desperate new breed of visitor. "There were many of them, and some had guns and ammunition," Kambale remembered. "Like that, the population increased, and these people had no food and had to look for charcoal, wood for fire, even meat in the park." One armed group begat another. The distinctions blurred. Congolese soldiers deserted their posts and disappeared into the bush. Some joined Mai-Mai militias, which at times confederated with the Hutu-based FDLR against all comers, including the rangers who sought to deny them a livelihood inside the park.

As the Mobutu regime collapsed in 1997, so did any semblance of governmental structure. Virunga's rangers saw their salaries slashed. They had to fend for themselves. Many did so by taking money from poachers, who would brazenly call a compromised ranger and direct him to come pick up a slaughtered buffalo. Other rangers distributed tickets to locals, allowing them to harvest wood for charcoal with the understanding that a generous slice of the profits would be handed over to Virunga's uniformed men—and make its way up the food chain.

Even in this moment of relative calm, ghosts have claimed far more of the central sector than its decaying hotel. The former ground zero for park tourists, Rwindi station, is still a no-go zone. The walls of the sector commander's office are pocked with bullet holes. A UN military base lies nearby. Signs posted throughout Rwindi urge the locals to report any signs of a ranger's suspicious activity.

Late one morning Kambale and two other armed rangers drove me to Vitshumbi, a village on the south bank of Lake Edward, inside the park's boundaries. Conceptually, Vitshumbi is a fishery with 400 boats licensed to fish on the lake, supporting about 5,000 people. In reality, Vitshumbi is a squalid town with thousands of boats and perhaps 40,000 residents with no electricity or running water.

What it does have are Mai-Mai militias, which have offered protection to Vitshumbi's fishermen and farmers in exchange for a surcharge. Behind the militias, Kambale and other rangers say, are politicians who supply the outlaws with boats and weapons. "It used to be that the Mai-Mais just fought with spears and machetes," a young ranger stationed in Vitshumbi told me. "Now the politicians have given them guns." The ranger pointed to a bullet scar on his left bicep, a souvenir from a recent encounter with Mai-Mais on Lake Edward. One ranger and seven Congolese soldiers had been killed.

Elsewhere during my three weeks in the park, unrest flickered ominously like a rogue torch in the night. From Vitshumbi a ranger boat was waiting to take me north to the hippo enclave of Lulimbi. Minutes before embarking, I learned that my trip was canceled by the park's director of security, who called to say the lake was not considered safe from attack. Three days before that, in the southern sector where the mountain gorillas reside, an angry phalanx of at least 300 villagers had blocked the road outside the Mikeno Lodge for hours, saying that the park had failed to compensate them

for cutting down some of their trees that would have interfered with newly installed electrical lines. Adding to the villagers' disquiet was the fact that a thousand or more Rwandan Army soldiers had quietly crossed the border to hunt down FDLR fighters. A week later, upon arriving in the northern sector, I watched as a squadron of rangers and Congolese soldiers made out for Mayangose, northeast of the city of Beni, where they forced out an encampment of 800 squatters who had been egged on by politicians to seize parkland.

A few hours after Kambale had escorted me from Rwindi to Vitshumbi in a park jeep, the central sector's accountant left Rwindi for the day and drove home on his motorbike along the very same road—only to be waylaid by three men who jumped into his path and pointed Kalashnikovs at his chest. They tied his hands and dragged him off into the bush. Later that evening the accountant's family received a call demanding a $5,000 ransom.

Word reached park headquarters. More than a hundred rangers and Congolese soldiers were dispatched to the central sector, along with aerial reconnaissance and tracking bloodhounds and spaniels. The dogs located the accountant's scent. The pursuers set up a perimeter and began firing shots into the air. The kidnappers fled. Ambling through the bush, the accountant came upon the welcome sight of his fellow park employees. It was, for him, a harrowing ordeal—but also a show of swift action by de Merode, the man Kambale refers to as "our only hope."

AS HEROIC FIGURES GO, the 46-year-old Emmanuel de Merode seems somewhat miscast. Milky faced, thin, and mild in manner, the Virunga director and chief warden does not exactly fill a room; he does not even fill his uniform. When I first met him, at a National Geographic Society event in Washington, D.C., I was sure he must be someone else, waiting alongside me for the actual de Merode to materialize. By ancestry, he's a Belgian prince, a title bestowed on his family because a forefather helped the country gain independence from the Netherlands. From this limited appraisal, one could imagine de Merode best suited to a life beside a fireplace with a glass of burgundy, sweater clad, rather than in one of the world's most notorious conflict zones. But de Merode was born in Africa, spent his youth in Kenya, trained as an anthropologist, and has worked his adult years in conservation, much of it in Congo.

Beneath de Merode's baggy ranger shirt are two sets of entry and exit wounds; one bullet went through his left lung and the other his stomach. He acquired these injuries in April 2014, while driving from Goma back to the park on a deserted and poorly paved stretch of marshy road about three miles south of Rugari. The would-be assassins were never found. (The investigation, his associates note with fatalistic eye rolls, is ongoing.) News of the shooting descended upon eastern Congo "like a thunderclap," recalled Kambale. Today de Merode's friends notice the occasional cough—the only utterance of lingering discomfort.

De Merode became Virunga's director in 2008, at the park's precise nadir. The previous director had been arrested earlier that year and accused of participating in a charcoal-trafficking ring and planning the gorilla massacre. (He was not convicted, for lack of evidence.) About six months earlier, the park's new occupier had become the CNDP, a militia backed by Rwanda to take on the FDLR. De Merode's first order of business was an audacious act—to show up unarmed at CNDP headquarters to ask that his rangers be permitted to return to the park. The militia's leader, Laurent Nkunda, granted the request. De Merode then set to work cleaning up the ranger force. He slashed its ranks from 1,000 to 230 (later bringing the number back up to 480, including 14 women) and hiked monthly salaries from a pitiable five dollars to a decent living wage of $200—"enough," he said, "to justify a zero tolerance of corruption."

De Merode then began trying to improve relations with the local population. He listened to the people's complaints. For decades the park had promised that half of each tourist dollar would go back to the community. Where was

that money being spent? The roads, the schools, the hospitals were steadily deteriorating. Meanwhile, elephants were destroying crops.

"Before de Merode started showing up, we didn't even know the park had a director," a fisherman in Vitshumbi told me. "Now you see the rangers have clean uniforms, good weapons. You see what a difference he's making." The director even sat down with Congolese militia groups—though with mixed results. "If we can have a constructive dialogue with militias that keeps people safe and keeps rangers from being killed, we're willing to do that," de Merode said. "But often it's been disappointing, because it hasn't been an honest dialogue."

Regardless, his presence has registered with his adversaries. In 2012 a ranger major named Shadrack Bihamba was cornered by Mai-Mais on the shore of Lake Edward and led at gunpoint into the bush. Bihamba said the militia's leader was worried, telling the others: "He's an officer. If we kill him, de Merode will move heaven and Earth to annihilate us." He instructed his men to release Bihamba. "Even though they're Mai-Mais and have their strength in the bush," Bihamba said, "they still fear de Merode, because they know he has the entire population behind him."

Still, de Merode knew something that some of his enemies did not—which was that his growing prominence alone could not sustain the park. It needed money to enforce the law and make permanent allies out of the park's neighbors. The only way to achieve the latter, de Merode

At the Senkwekwe Center for mountain gorilla orphans, in Rumangabo, rangers live around the clock with four juveniles whose parents were killed. The rangers see their families only every few weeks and are very close to their charges. Since no mountain gorilla orphan has ever been successfully returned to the wild, they will always depend on humans.

concluded, would be "to use the park as a basis for creating mass employment, but in a way that wouldn't damage the park." That goal led him to the park's northern sector—and specifically to the Butahu River, which cascades from the glacial peaks of the Rwenzori Mountains into the outskirts of Mutwanga village, a typically meager community that lacked electricity. In 2010 the park began hiring villagers to dig canals and lay the foundation for what would become Virunga's first hydroelectric plant. For $110, the park would connect a Mutwanga household, which could then buy electricity on a modest pay-as-you-go basis. In 2013 the power came on, and de Merode held his breath.

I had not seen Mutwanga before it had electricity, and it hardly resembled a boomtown when I spent a day touring the mud-splattered village. Still, the residents spoke of the change as transformative. What it had cost in a single day to power their shops in generator fuel now bought an entire month's worth of electricity. Students could do their homework in the evening. The hospital functioned at all hours. People were buying irons, televisions, and CD players. The owner of a computer-repair store was renting out DVDs and preparing to open the town's first Internet café, so that villagers would no longer have to drive an hour to Beni to send an email. A couple from Beni actually moved to Mutwanga in 2014 to realize their dream of owning a small printing shop. All of this despite the fact that only 500 of the community's 2,500 households have been hooked to the hydroelectric plant's modest 400-kilowatt output. And while de Merode's team makes plans to accommodate the long waiting list, in April a factory powered by the park began making soap. It employs about a hundred workers from the area. "Mutwanga became our laboratory test," de Merode said.

A second, larger hydroelectric plant came on line in December, and by the end of 2018 two others should be running. Those four plants would bring de Merode halfway toward his goal of producing a hundred megawatts of power. Selling that electricity, he predicts, would "enable us to ensure that the park will be financially sustainable for the next one hundred years." Enough additional revenue would be generated to invest millions a year in community projects and conservation efforts in other Congo parks.

De Merode's expectation is that electricity will catalyze economic development. "The reason there isn't industry is there's no access to cheap energy. That's really what the park can offer," he said. That this will lead to a flowering of entrepreneurship is far from a sure thing. "There aren't any business role models here," the soap factory's managing director, 29-year-old Leonard Maliona, told me. "Young people have nothing to aim for, other than being a politician or joining a militia."

The notion of Virunga as the region's "economic

Porters carry gear for tourists climbing Nyiragongo volcano, which has the world's largest lava lake. Money from tourism is one way the park contributes to local communities, but it also helps by sponsoring such projects as road construction and hydroelectric plants.

engine," to use de Merode's terminology, conjures up a spectacle that some may find unusual. Among other things, the scenario suggests that Congo's leaders have essentially consigned the fate of one region of their country to a single park and its director, who shares his Belgian heritage with the country's former colonial power. It also risks replacing a population's lingering hostility toward the park with an intense dependency on it. De Merode's gamble is unapologetically high stakes. And it rests heavily on young men who agree to beat their swords into plowshares and do an honest day's work on little farm roads like the one up to Bukima.

A ranger surveys a new lava field created by Nyamulagira, the most active volcano in Africa. The 10,033-foot peak, with a new lava lake in its caldera, erupts roughly every two years. In the foreground is a sulfur deposit from a recent eruption. The park encompasses an extremely diverse landscape, including glaciers and savannas, as well as volcanoes.

BRENT STIRTON, REPORTAGE BY GETTY IMAGES

THE TWO LABORERS, both in their mid-20s, wore fluorescent orange vests over their T-shirts and were filling potholes on a shady stretch of the road. The taller of the two, with hooded eyes, was named Bushe Shukuru; the shorter one, with a quiet but easy smile, went by Gato Heritier. The two were childhood friends. Each time armed insurgents came, causing the villagers to run for miles until the sounds of gunfire had diminished, the teenagers would make it a point to search for each other at the refugee camps. On separate days during the spring of 2013, first Shukuru and then Heritier were caught in their village by M23 soldiers who tied their arms and marched them off to the place where they again found each other: the military base in Rumangabo, near the park's southern sector, which had been taken over by M23. They joined a thousand or so young men who were also involuntary conscripts at the rebel faction's training camp.

The commanders told Shukuru, Heritier, and the others that the government had failed eastern Congo. With proper training, they said, M23's new warriors would take over the region and then advance westward and conquer Kinshasa. They were taught how to shoot, march in formation, attack, and withdraw. For their shortcomings, they were beaten with wooden sticks—some of them to death, right in front of the others. Others died of starvation from the paltry daily rations: a single cup of cornmeal. Three months of this, and then Shukuru and Heritier were sent to battle. By November both could see that M23 stood no chance against the army and UN forces. They fled and found each other again that month, in a UN compound.

Now here they were, in matching vests. The road they tended was, by rural Congolese standards, almost sleek. Yam and corn farmers, cattle and goat herders, schoolchildren and churchgoers negotiated the sloping path in half the time it once took. "The road's really had a big impact," said Heritier as he sat on a log and wiped the sweat off his face. Shukuru agreed: "That's why I don't mind doing this job. You can tell it's helping this community."

But, they acknowledged, three dollars a day for eight hours of backbreaking work was not where they saw themselves for long. As a small

child, before he understood what life in eastern Congo had to offer, Heritier had imagined himself as "some kind of big guy. A doctor. Maybe even the president. I mean, why not?" If he saved his money, perhaps he could be a mechanic, and Shukuru might one day open a shop of some sort. A small and quiet, but honest and peaceful destiny that began with this road, leading uphill to the mountain gorillas. From there the peace would spread northward to Rwindi station, where Theo Kambale was also daring to harbor modest dreams. Recently, he had heard, a lioness and her cub had been spotted watering themselves on the banks of the Rutshuru River. And he had heard something else—that along with the slow return of wildlife, the long-abandoned Rwindi Hotel may also return, if the park can find the money to restore it.

It was, as Kambale told the young men on the road, the beginning of life. □

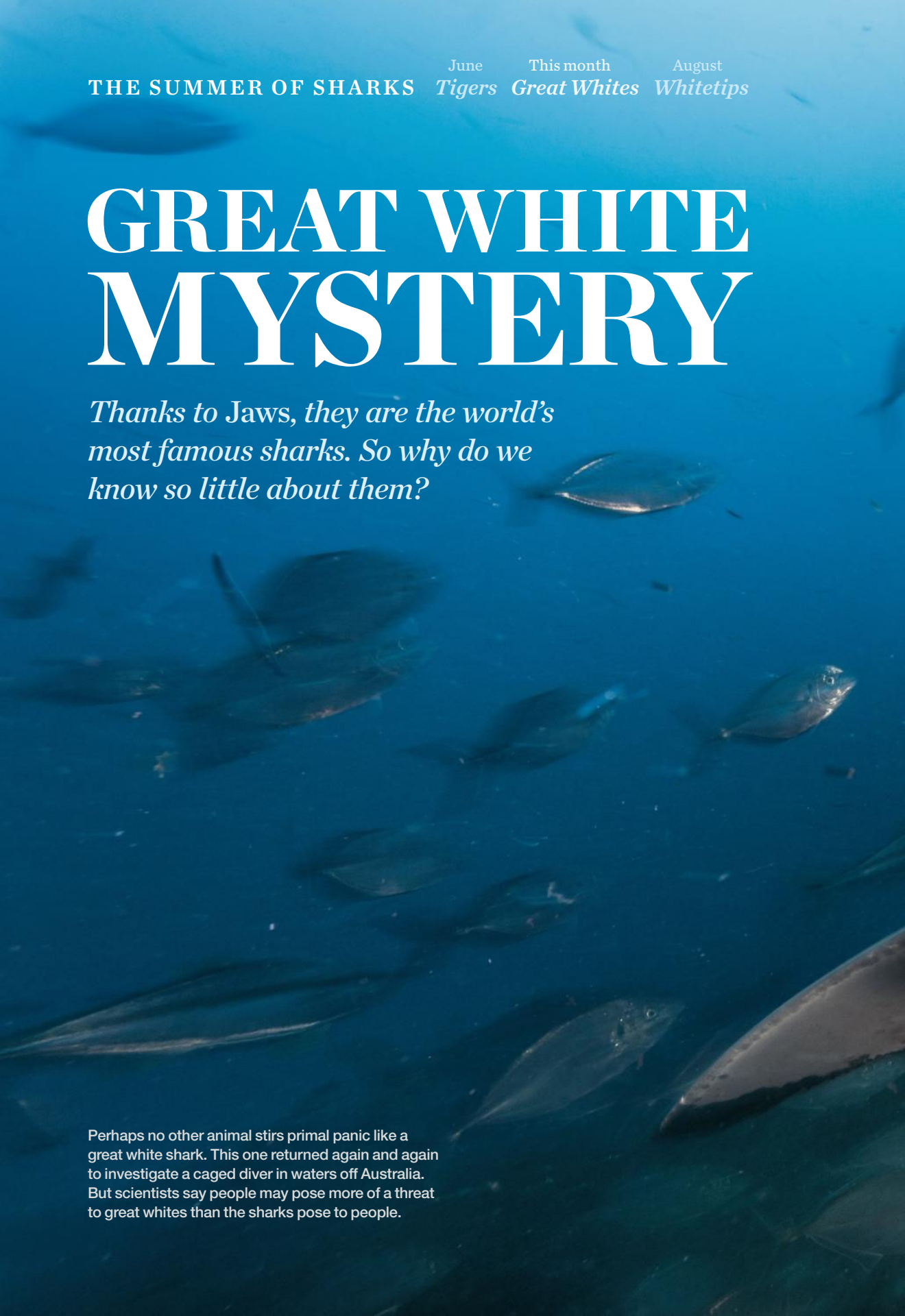
BYBA SEPITKOVA

Photographer **Brent Stirton** first went to Virunga in 2007 to see a group of rangers who were fighting to protect the park "against fearsome odds." He has since returned many times.

What keeps drawing you back to Virunga? The dedication of those men and the rangers who have come after them. They deserve to be known; I am honored to think of them as my friends. They are the best of a nation that has too often experienced the worst humanity can offer.

GREAT WHITE MYSTERY

Thanks to Jaws*, they are the world's most famous sharks. So why do we know so little about them?*



Perhaps no other animal stirs primal panic like a great white shark. This one returned again and again to investigate a caged diver in waters off Australia. But scientists say people may pose more of a threat to great whites than the sharks pose to people.

The clear waters off Australia's Neptune Islands are one of the best places in the world to see great white sharks. This one is cruising past a ray in a kelp forest.

A great white eyes a camera in a seal decoy near Cape Cod. This is a rare high-quality photograph of one in these waters. Great whites here are difficult to photograph because they aren't attracted to chum.

By Erik Vance
Photographs by Brian Skerry

Meeting a great white shark in the wild is nothing like you expect it would be. At first glance it's not the malevolent beast we've come to expect from a thousand TV shows. It's portly, bordering on fat, like an overstuffed sausage. Flabby jowls tremble down its body when it opens its mouth, which otherwise is a chubby, slightly parted smirk. From the side, one of the world's greatest predators is little more than a slack-jawed buffoon.

It's only when the underwater clown turns to face you that you understand why it's the most feared animal on Earth. From the front its head is no longer soft and jowly but tapers to an arrow that draws its black eyes into a sinister-looking *V.* The bemused smile is gone, and all you see are rows of two-inch teeth capable of crunching down with almost two tons of force. Slowly, confidently, it approaches you. It turns its head, first to one side and then the other, evaluating you, deciding whether you're worth its time. Then if you're lucky, it turns away, becoming the buffoon again, and glides lazily into the gloom.

There are more than 500 species of sharks, but in popular imagination there's really only one. When Pixar needed an underwater villain for its animated film *Finding Nemo,* it didn't look to the affable nurse shark or the aggressive bull shark. Not even the tiger shark, which would be more appropriate in Nemo's coral-reef home. It was the great white shark—with its wide, toothy grin—that was plastered on thousands of movie billboards across the world.

The great white shark is the ocean's iconic fish, yet we know little about it—and much of what we *think* we know simply isn't true. White sharks aren't merciless hunters (if anything, attacks are cautious), they aren't always loners, and they may be smarter than experts have thought. Even the 1916 Jersey Shore attacks

A large great white explodes through the water near the Neptune Islands. Scientists identify these sharks by their dorsal fins, their scars, and the jagged line separating their white and gray halves.

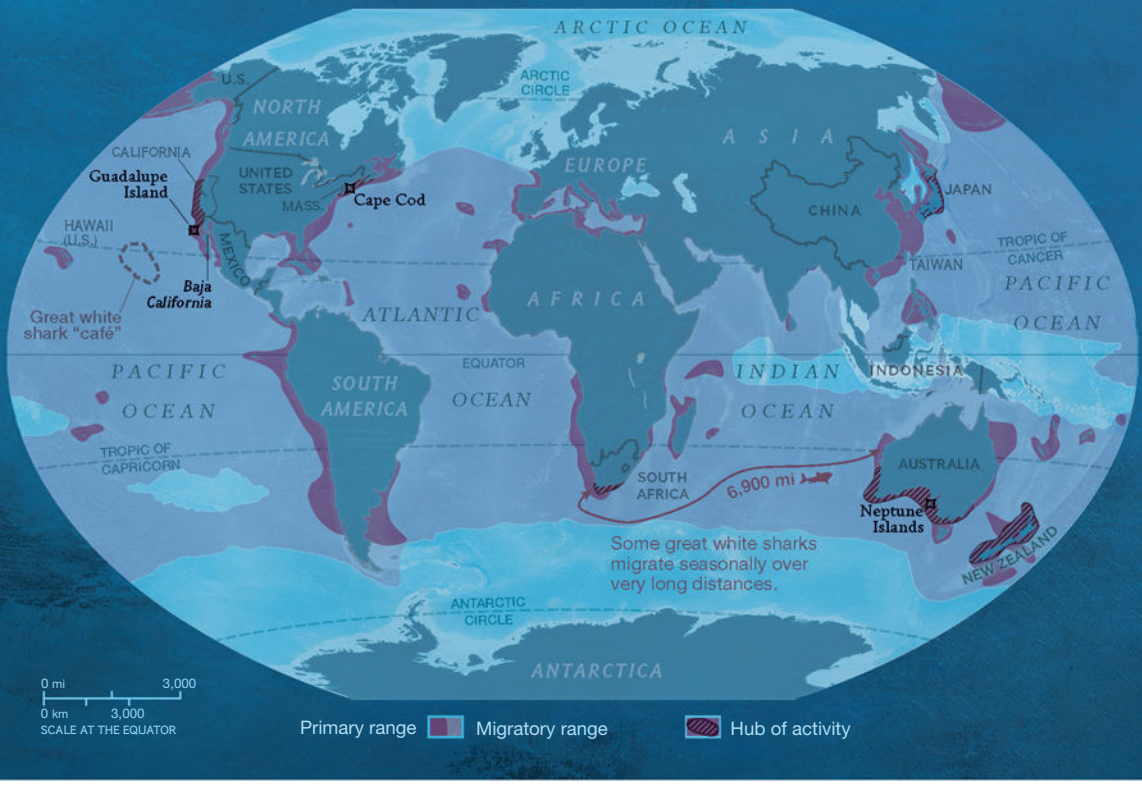
famously mentioned in *Jaws* may have been perpetrated by a bull shark, not a great white.

We don't know for sure how long they live, how many months they gestate, when they reach maturity. No one has seen great whites mate or give birth. We don't really know how many there are or where, exactly, they spend most of their lives. Imagine that a land animal the size of a pickup truck hunted along the coasts of California, South Africa, and Australia. Scientists would know every detail of its mating habits, migrations, and behavior after observing it in zoos, research facilities, perhaps even circuses. But the rules are different underwater. Great whites appear and disappear at will, making it nearly impossible to follow them in deep water. They refuse to live behind glass—in captivity some have starved themselves or slammed their heads against walls. (Several aquariums have released them for their own safety or because they were attacking tank-mates.)

Yet scientists today, using state-of-the-art technologies, may be on the verge of answering two of the most vexing mysteries: How many are there, and where do they go? Unraveling these mysteries could be critical to deciding how to protect ourselves from them and them from us. When we finally see the great white clearly from all angles, will the world's most fearsome killer deserve our fear or our pity?

The Realm of the Great White

The great white is one of six shark species that are endothermic, which means they can raise internal body temperatures over that of surrounding waters. This allows great whites to inhabit extreme depths as well as cold waters of higher latitudes, while still being able to function efficiently to capture swift and agile prey.

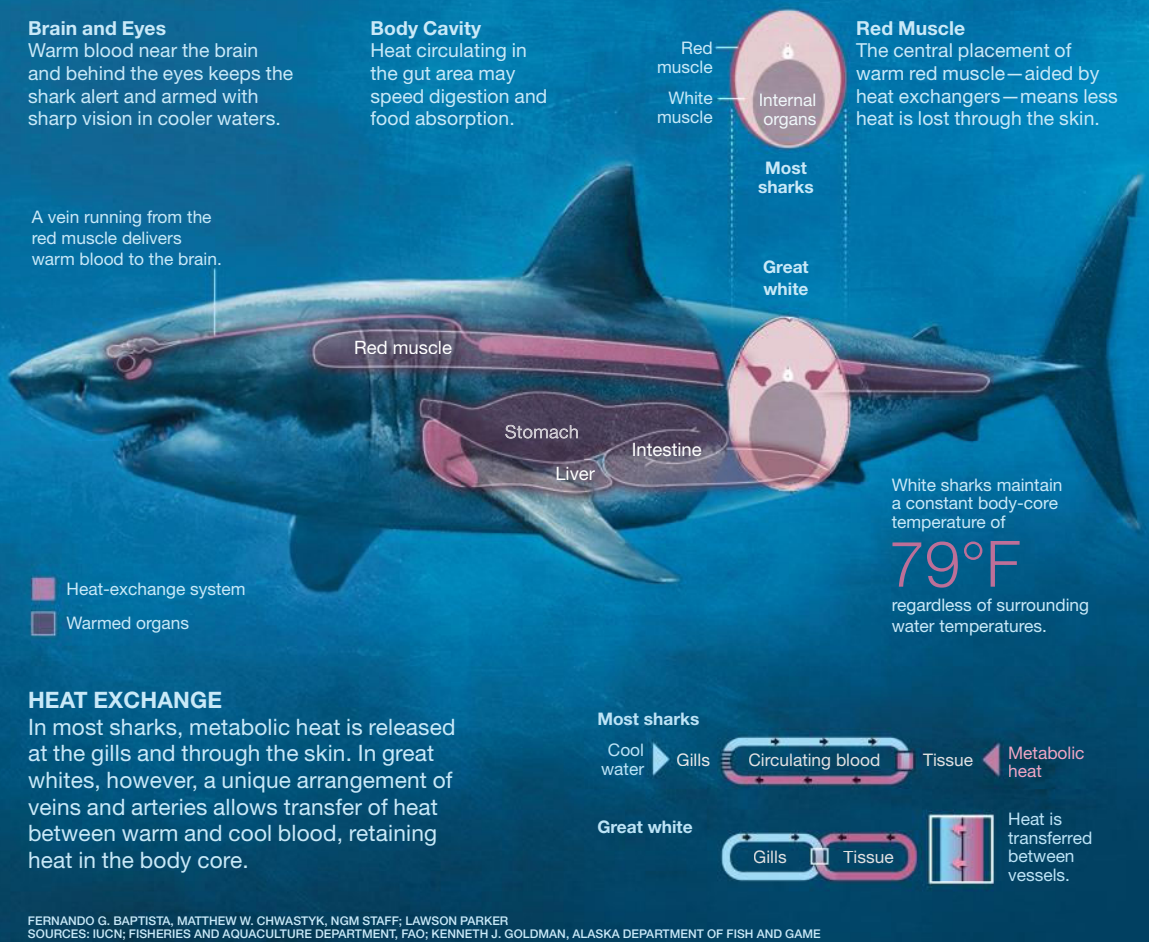


A 24-FOOT FISHING BOAT sits just off the southern tip of Cape Cod, Massachusetts, on a perfect summer afternoon. The passengers—three scientists, two paying customers, two journalists, and the boat's captain—lounge on the seats, looking off toward Nantucket. The voice of a spotter pilot flying 1,000 feet above breaks out over the radio in a sharp New England accent. "We've got a wicked nice shark over here to the south!"

Fisheries biologist Greg Skomal perks up. He's standing five feet off the bow on the pulpit, a fenced-in walkway resembling a pirate's plank. If this were a Hollywood movie, he'd have a harpoon and a peg leg. Instead he carries a GoPro camera attached to a 10-foot pole. He grins like a little kid as the captain guns the engine.

Before 2004 hardly anyone in modern times saw great white sharks in the waters off the East Coast. Occasionally one would appear near a beach or in a fishing net, but they were anomalies. Elsewhere, great whites congregate seasonally around five "hubs" or territories, including California's coast down to Mexico's Baja California, South Africa's southern shores, and Australia's southern coast, where they gather to feed on seals. But there's been no hub on the East Coast, nor have there been many seals. Sharks here were wanderers without a home. Then, in 2004, a single female found her way into shallow inlets and shoals near Woods Hole, Massachusetts.

For Skomal, who'd been tagging other sharks for 20 years, this was the chance of a lifetime—a great white in his own backyard. "I thought it was a fluke. This will never happen again," he says with his broad, boyish grin under ruffled salt-and-pepper hair. Over the next two weeks



FERNANDO G. BAPTISTA, MATTHEW W. CHWASTYK, NGM STAFF; LAWSON PARKER
SOURCES: IUCN; FISHERIES AND AQUACULTURE DEPARTMENT, FAO; KENNETH J. GOLDMAN, ALASKA DEPARTMENT OF FISH AND GAME

Skomal and his colleagues followed the shark, which they named Gretel after the lost girl in the fairy tale, and affixed an electronic tracker on her. Tracking a white shark across the Atlantic Ocean offered a chance to solve so many riddles. But 45 minutes into the journey, Gretel's tag malfunctioned and popped off. "I went from this superhigh to this really deep low, because I was convinced that this was the shot in my career to study a white shark," Skomal says.

It wasn't. Over the next few years he thought a lot about Gretel and wondered whether she was indeed alone. Then, on Labor Day, 2009, everything changed. A pilot saw five great whites off the cape. Over that weekend Skomal tagged them all. "I absolutely freaked out. My adrenaline was pumping. My heart—I could feel it just pounding in my chest. This was everything I was dreaming of."

White sharks have returned every summer since, leading some to call Cape Cod the sixth hub. How many great whites are there? For that we turn to the hub running from California to Baja California. The effort to count sharks there was pioneered by Scot Anderson while he was a volunteer seabird scientist in the mid-1980s on an island west of San Francisco's Golden Gate Bridge. Anderson and others have tracked the sharks—at first by sight, then by acoustic tags, and most recently with satellites. During the past 30 years, teams have assembled thousands of observations of individual sharks recognized by the shape and marks of their dorsal fins, while others have used the distinctive line between their gray bodies and white underbellies. Scientists know where the sharks congregate and how

Searching for seals, two sharks swim near the Neptune Islands. Great whites do not live in groups, nor are they purely solitary creatures. Sometimes they congregate near food.

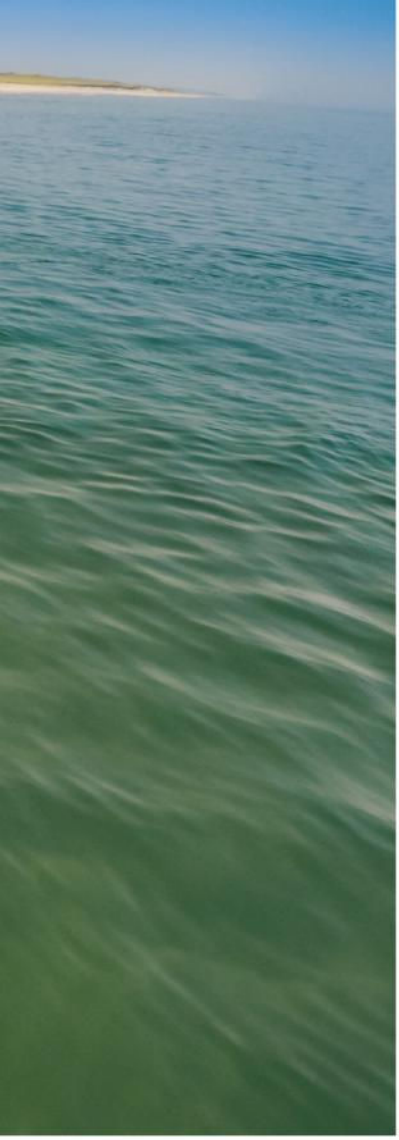
Biologist Greg Skomal tries to record video of a shark near a popular swimming area off Cape Cod. For the first time in modern history, great whites have begun regularly returning to the waters of this vacation spot.

they feed. And each year most sharks they see are the ones they saw in previous years.

This raised an intriguing question: With enough observations, could you use the sharks you see to estimate how many you can't see? In 2011 a team in California did just that and came up with just 219 adults in California's most shark-rich region. Even among top predators, generally less abundant than their prey, that's a tiny number. The study shocked the public and came under immediate attack from other experts.

Of course, counting great whites is a lot harder than counting land animals or even marine mammals. So scientists make massive assumptions about shark movements and then extrapolate. In California the biggest assumption was that a few feeding grounds were representative of the entire hub. Other teams crunched the same data using different assumptions, and one study estimated about 10 times more sharks. (That count was bolstered by adding juveniles, which the first excluded because so little is known about them.) Pretty soon scientists began quantifying white sharks in the other hubs. A team in South Africa estimated the population there at around 900, while another team put Mexico's Guadalupe Island population,

Grant Brian Skerry's fieldwork was funded in part by your National Geographic Society membership.



part of the California hub, at just 120 or so.

Are these large numbers or small? Are great whites thriving or dwindling? The world has about 4,000 tigers and 25,000 African lions. Using the lowest estimates, global great white numbers resemble the estimate for tigers, an endangered species. Using the highest estimate, the population is closer to that of the lions, which are classified as vulnerable. Several experts see them heading toward extinction; others see a positive trend. Some say rising seal populations are a sign that great whites are nearly gone, while others say more seals mean more sharks. Aaron MacNeil, an Australian statistician who crunches shark data, says the appearance of sharks around Cape Cod and the increased activity in the Southern Hemisphere suggest the latter. "I haven't seen any evidence in the last decade that white sharks are declining," says MacNeil. "Yes, there is a historical depletion of white sharks. But the story is not that they are going extinct. The story is that they are probably increasing very, very slowly."

There's reason to be hopeful. Few if any fishermen target great whites today, yet a global pact, the Convention on International Trade in Endangered Species, gives white sharks its second strongest conservation rating because fishermen catch them unintentionally. With numbers so low, even accidental catches can play havoc with the species, which, as a top predator, has an ecologically important role in managing the oceans.

TO UNDERSTAND WHETHER great white sharks need our protection, we must know not only how many there are but also where they go. Their migrations aren't neat, like a bird's or a butterfly's. They're messy, with one hugging the coast while another zigzags hundreds of miles out to sea. Many, but not all, seem to seasonally move between warm and cold water. And the paths seem different for males, females, and juveniles.

Today, with long-term, long-distance tags that can communicate via satellite, scientists are finally getting some clarity. For years scientists have noticed that adult great whites in California and Mexico quit the coast in late fall. Now we know where they go: deep water in the middle of the Pacific Ocean. Why they visit this great white shark "café" remains unclear. "I call it Burning Man for white sharks," says Salvador Jorgensen, a biologist who studies factors that drive great white migration and ecology. "They are heading out to what some people call the desert of the ocean, and what the hell are they doing out there?"

One possible answer is mating, which might explain why no one has ever observed it. The area is roughly the size of California and thousands of feet deep, which makes it hard to monitor sharks there. But satellite tags tell us that the females swim predictable straight patterns while the males swim up and down in the water column, possibly searching for mates.

A great white bites a seal decoy off Cape Cod. Sharks often attack cautiously, apparently fearing injury from a seal's claw. Frequently they will bite, then back off and allow the prey to bleed to death.

Thus a rough sketch of the lives of California white sharks is forming. After spending the summer and fall gorging on seals, they head out to the deep ocean to breed, relying on energy stores to live. The males then swim back to the coast while the females wander to unknown places, where they remain for another year or so, perhaps to birth their young. Newborn sharks then show up at feeding grounds—say, the waters off Southern California—devouring fish until they are big enough to join their elders in the north or south hunting seals.

It's not a perfect picture. Females and males aren't in the café together for long, and we don't know where the babies are born. But it explains a lot. For example, as a population rebounds, its young become plentiful, which is likely why Southern Californians have encountered a lot of sharks lately. Yet it's tougher to figure out elsewhere. Australian sharks forage along the southern coast but don't seem to have a pattern or café. And in the Atlantic we know even less. "We've got wanderers, and we've got coastal sharks. And what dictates which, I have no idea," Skomal says.

Even though he doesn't understand their migrations yet, Skomal is sure that white sharks have a long history here. At his office in New Bedford, just west of Cape Cod, he opens a document that compiled studies of seal bones from Native American archaeological sites along the eastern seaboard. The discarded bones suggest that seal populations crashed from overhunting perhaps a century before the Declaration of Independence. In other words, we've had very few Atlantic gray seals throughout the United States' 240-year history. Today, thanks to the Marine Mammal Protection Act, seal colonies now populate New England. And when the seals returned, the sharks came home as well.

Ready for some sharks in action? Go to *ngm.com/Jul2016* to watch video of photographer **Brian Skerry** on assignment off Cape Cod, using a seal decoy to photograph the predators.

ONE BRIGHT AUGUST MORNING I board a two-seater plane with Wayne Davis, a veteran spotter pilot for tuna and swordfish who now helps scientists track down white sharks. Unlike the hubs, the water here is so shallow that sharp eyes can spot them from the air. In just 30 minutes of flying we see seven, all patrolling beaches where gray seals are foraging in open waters. On the way back Davis and I fly past several beaches a mile or so to the north packed with vacationers.

So far locals have embraced their new neighbors. There are stuffed animals, T-shirts, posters, and a community art exhibit called "Sharks in the Park." Even the new high school's mascot is a great white. Most of the time the sharks are shown from the side—cheerful, buffoonish. Experts warn, though, that at some point someone here will meet the other version—the one with teeth.

Attacks on people are incredibly rare. In waters off California, the chances of a surfer being bitten by a great white shark are one in 17 million; for swimmers, it's even rarer—one attack in every 738 million beach visits, according to a recent Stanford University study. On Cape Cod, fatalities may not be a question of if, but when. The last lethal shark attack off New England was in 1936, but there have been several close calls recently. A swimmer there was bitten on both legs in 2012, and two paddlers in Plymouth were knocked from their kayaks in 2014, although they escaped unscathed.

If a more serious attack happens, Massachusetts will join the other hubs in weighing the benefits versus the dangers of sharks in their waters.

It may be that great white sharks are rebounding across the world: following the bigger seal and sea lion populations, re-establishing themselves in their old hunting grounds, reclaiming the coasts they nearly lost.

Then again, it may be that great whites today are hanging over the abyss of extinction, clutching the edge by the skin of their jagged teeth. Will we look past our fear and reach out a hand to this creature? Can we take pity on the pitiless eyes of a monster? □

SAVING SHARKS

A CAMPAIGN TO STOP FINNING

Thousands of shark fins are laid out in the sun in Hong Kong. Once dry, a fin can stay in storage for years before it's boiled and its spines are extracted to make soup. The spines have no flavor, but they add texture similar to that of a bean sprout.

A hammerhead shark is pulled aboard a fishing boat 500 miles off the coast of Indonesia. Its flesh is not worth much, but its fins could fetch $100 a pound. The fishermen grab the shark, slice off its fins, and throw the animal, still alive, back into the sea to sink to the ocean floor.

According to some estimates, 100 million sharks from a variety of species may be killed annually, mostly to feed China's demand for shark fin soup, scientists say. Historically most fins have gone to southern China, where the soup is a popular wedding dish. But an anti-fin campaign has emerged, using celebrities such as actor Jackie Chan and former NBA star Yao Ming. Some say this effort may have cut Asia's shark fin demand by 70 percent. The Chinese government has outlawed shark fin soup at government events. But it's not clear whether the wholesale slaughter of sharks has really slowed. Fisheries scientist Daniel Pauly says the government action "is enough to eliminate finning from the radar of Western organizations. And it may continue under the radar until the last shark is caught." *—EV*

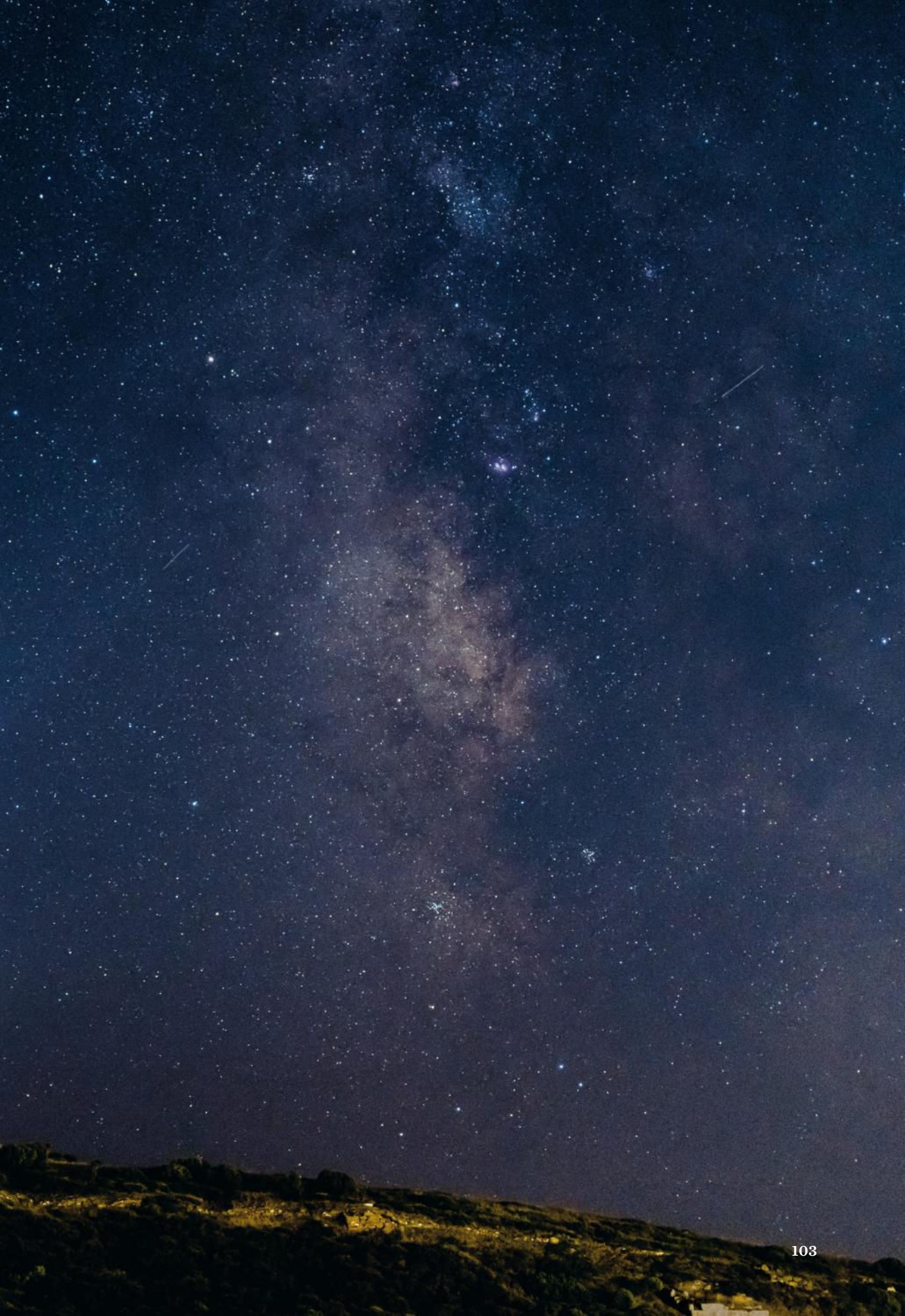
PHOTOS: ANTONY DICKSON, AFP/GETTY IMAGES (TOP); PAUL SAKUMA, ASSOCIATED PRESS

Ancient Greeks believed that gods played a role in all life, from realms above to the underworld below. Over time, people embraced new ideas of the afterlife in a more mystical, personal way.

GREECE, GODS, and the GREAT BEYOND

Floodlights illuminate the temple of Poseidon, god of the sea, at Cape Sounion, Greece.

VINCENT J. MUSI, ARCHAEOLOGICAL SITE OF SOUNION



By Caroline Alexander
Photographs by Vincent J. Musi and David Coventry

The world of ancient Greece

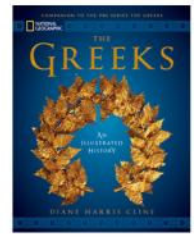
was filled with gods, led by the towering Olympians—Zeus, Hera, Apollo, Poseidon, Athena, and other giants of mythology. Alongside worship of these divine inhabitants of Olympus were hundreds of cults focused on local deities and heroes.

People prayed to these gods for the same reasons we pray today: for health and safety, for prosperity, for a good harvest, for safety at sea. Mostly they prayed as communities, and through offerings and sacrifice they sought to please the inscrutable deities who they believed controlled their lives.

But what happens after death? In this, the ancients looked to Hades, god of the underworld, brother of Zeus and Poseidon. But Hades gave no reassurance. Wrapped in misty darkness, cut by the dread River Styx, the realm of Hades ("the unseen") was, the poet Homer tells us, a place of "moldering horror" where ordinary people—and even heroes—went after they died.

Sympathetic interest in the human condition eventually led the Greeks to adopt new forms of religion and new cults. No longer seen as a joyless fate, the afterlife became more of a personal quest. Mystery cults, shrouded in secrecy, promised guidance for what would come after death. The mystery rites were intensely emotional and staged like elaborate theater. Those of the great gods on the Greek island of Samothrace took place at night, with flickering torch fire pointing the way for initiates. Guarded on pain of death, the rituals remain mysterious to this day.

By the fourth century B.C., cults had emerged that claimed to offer purification by cleansing initiates of the stain of humanity. The foundations for new religions were falling into place. And when Christianity swept the ancient world, it carried with it, along with guidance from a single deity, remnants of the old beliefs: the washing away of human corruption through mystic rites, the different fates awaiting the initiated and uninitiated, and the reverence for sacred texts.



Continue your tour of ancient Greece with a new National Geographic book, *The Greeks,* an expedition, and a TV special premiering June 21 on PBS. An exhibition celebrating 5,000 years of Greek culture is open until October 10 at the National Geographic Museum in Washington, D.C. Details are at *ngm.com/Jul2016.*

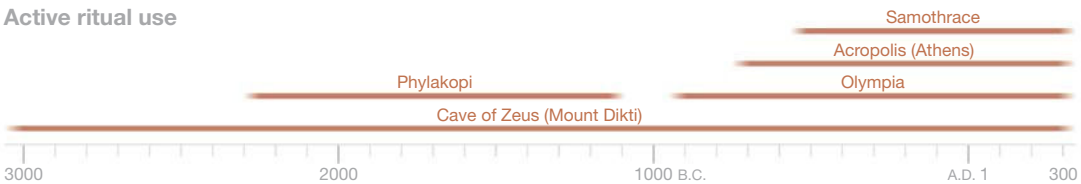
Atlas of Belief

The roots of religion in Greece date back thousands of years. Religious sites were devoted to civic cults or local gods, as well as to Greek traditions: festivals, oracles, pilgrimages, and ceremonies. The mystery-cult rituals at Samothrace, for instance, lasted from the sixth century B.C. through the dawn of Christianity. Sacred places also commemorated the legendary dwellings of the gods, such as Olympus.

Notable sanctuary or religious site

0 mi 60
0 km 60

PRESENT-DAY BOUNDARIES SHOWN
SITES IN BROWN ARE MARKED ON THE TIME LINE BELOW.

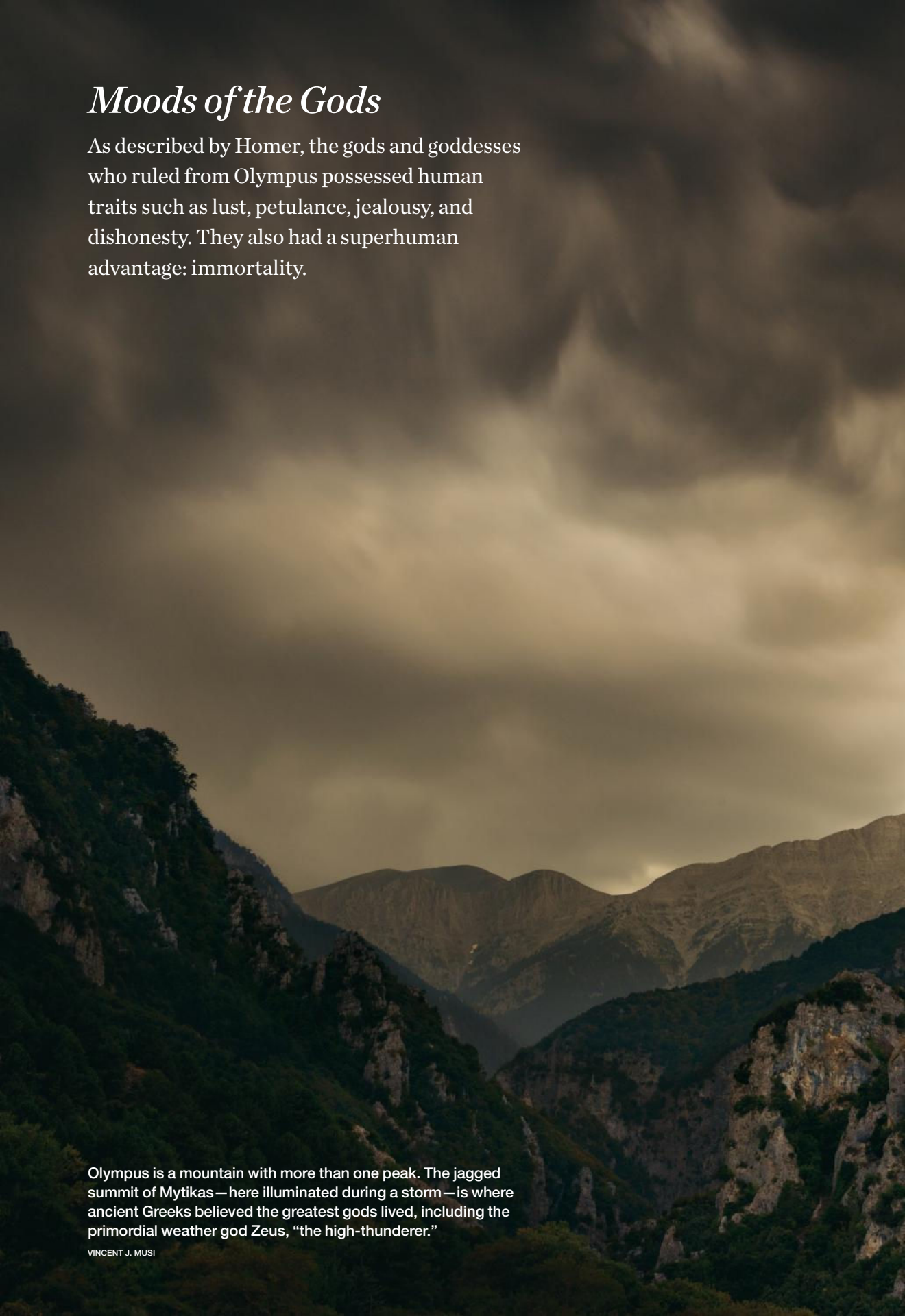


JEROME N. COOKSON, NG STAFF

SOURCES: SANDRA BLAKELY, EMORY UNIVERSITY; RICHARD TALBERT, UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL

Moods of the Gods

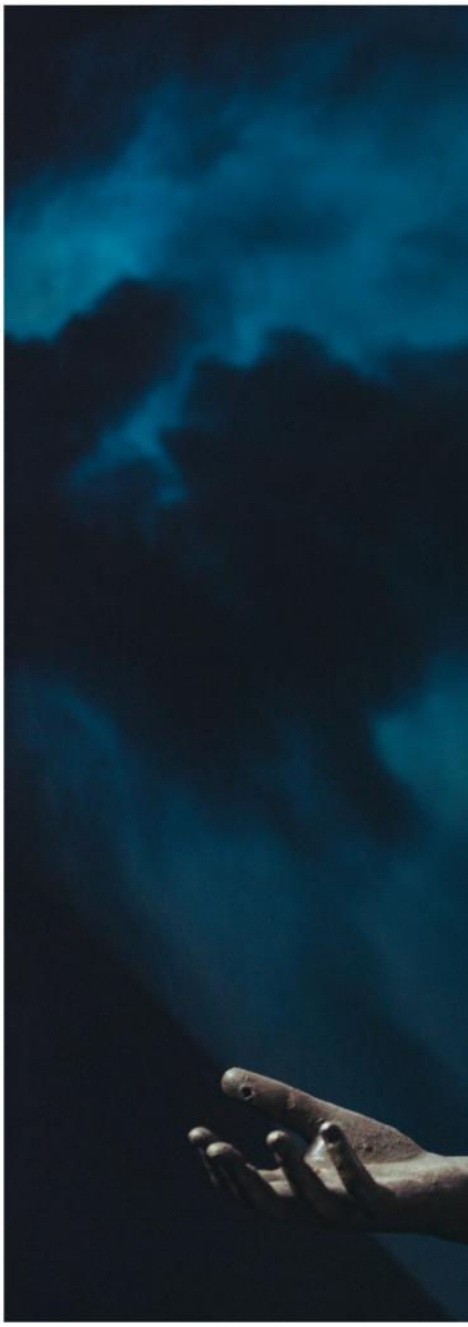
As described by Homer, the gods and goddesses who ruled from Olympus possessed human traits such as lust, petulance, jealousy, and dishonesty. They also had a superhuman advantage: immortality.



Olympus is a mountain with more than one peak. The jagged summit of Mytikas—here illuminated during a storm—is where ancient Greeks believed the greatest gods lived, including the primordial weather god Zeus, "the high-thunderer."

VINCENT J. MUSI

The 33 odes known as the Homeric Hymns extol the gods' virtues. Dionysus was "a stripling in the first flush of manhood"; Athena was a fierce foe who "loves deeds of war, the sack of cities and the shouting and the battle."



Here a drunken Dionysus—god of wine, theater, and music—leans on a satyr. The worship of this deity, which lasted through Roman times, often involved orgies and drinking contests.

DAVID COVENTRY, NATIONAL ARCHAEOLOGICAL MUSEUM, ATHENS

ATHENS ACROPOLIS, DELPHI, DODONA, SOUNION, AND ALL ARTIFACTS PHOTOGRAPHED WITH PERMISSION OF HELLENIC MINISTRY OF CULTURE AND SPORTS

This fourth-century B.C. bronze statue shows the goddess Athena, daughter of Zeus. Her intimidating battle attire included the head of the slain monster Medusa, worn on her chest.

DAVID COVENTRY, ARCHAEOLOGICAL MUSEUM OF PIRAEUS

Signs From Above

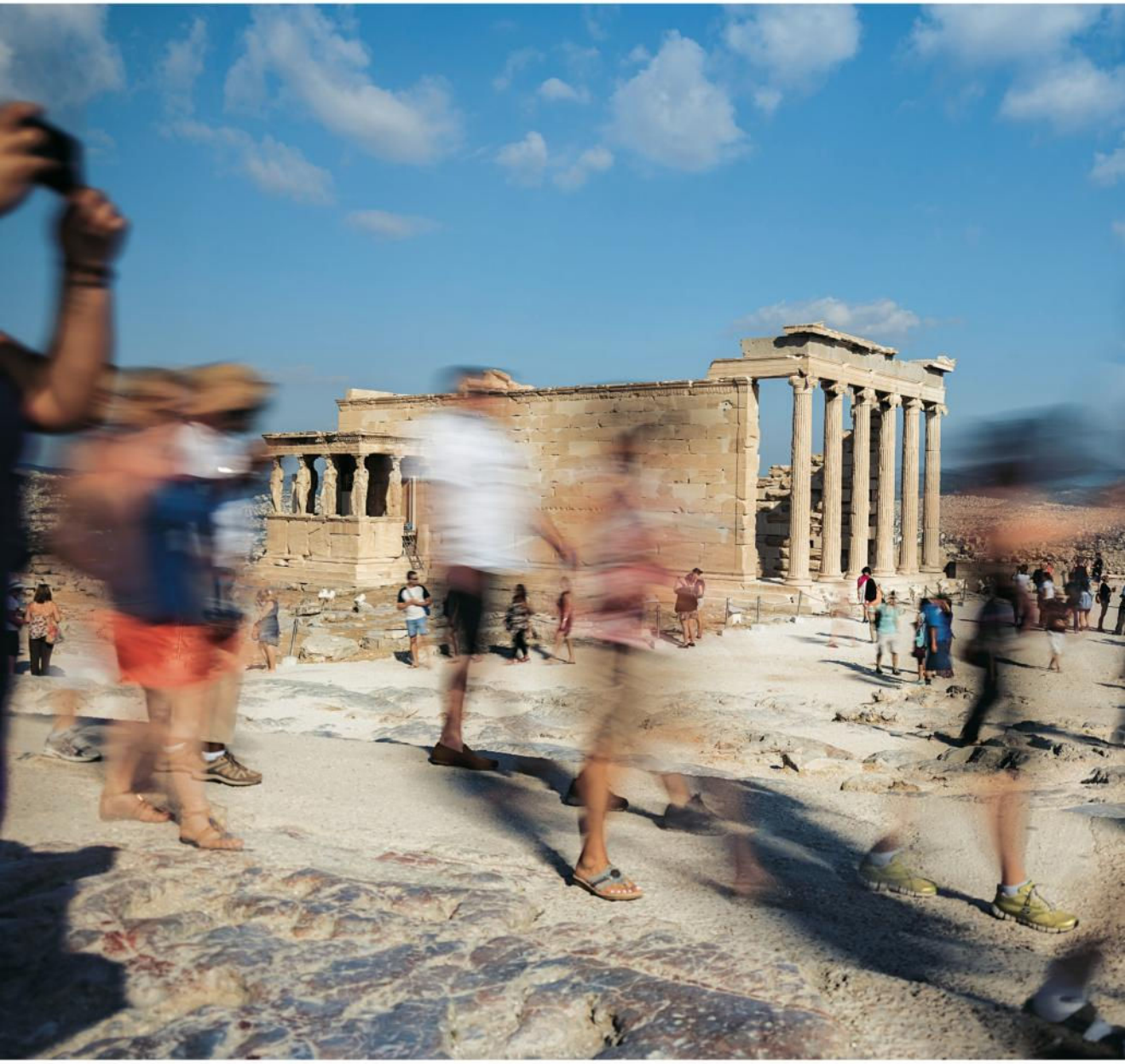
Greeks seeking guidance saw oracles as a direct line of communication with the divine. The gods' answers to their questions came in different ways—obscure riddles, omens in the form of birds or lightning, even the rustling of leaves.

The oracle at Dodona, in Greece's rugged northwest, was said to be the country's first. Here mortals posed questions to Zeus through a sacred oak, while priests interpreted the answers.

VINCENT J. MUSI, ARCHAEOLOGICAL SITE OF DODONA

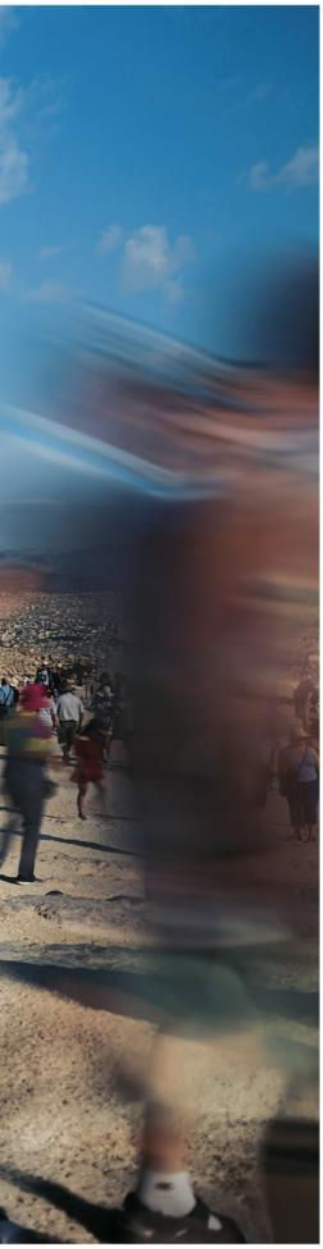
Twilight bathes the ruins of the sanctuary of Athena Pronaia at Delphi and its tholos, a circular building. Pilgrims may have offered sacrifices here before consulting the oracle of Delphi at the nearby temple of Apollo.

VINCENT J. MUSI, ARCHAEOLOGICAL SITE OF DELPHI



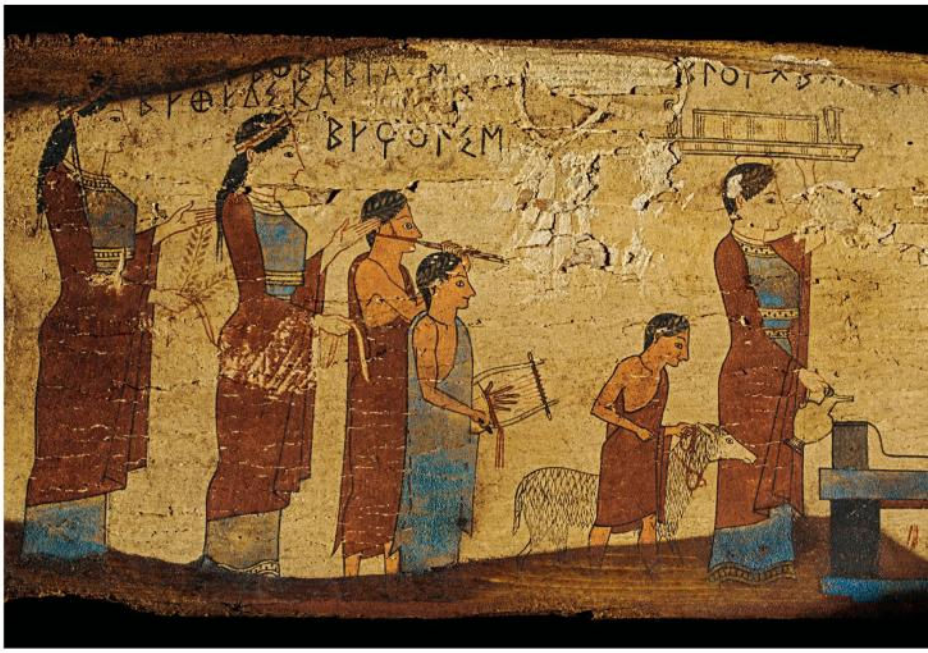
The Erechtheion, a temple to Athena, occupies the most sacred ground on Athens's Acropolis. Ancient Greeks held festivals, sacrifices, games, and religious processions at the site; today it's a magnet for tourists.

VINCENT J. MUSI, ARCHAEOLOGICAL SITE OF THE ACROPOLIS, ATHENS



Public Worship

Shared religious rites united ancient Greek villages and regions. Worship initially was communal, but as people sought meaning in life and hope for an afterlife, they were drawn to cults that stressed a more individual relationship with the divine.

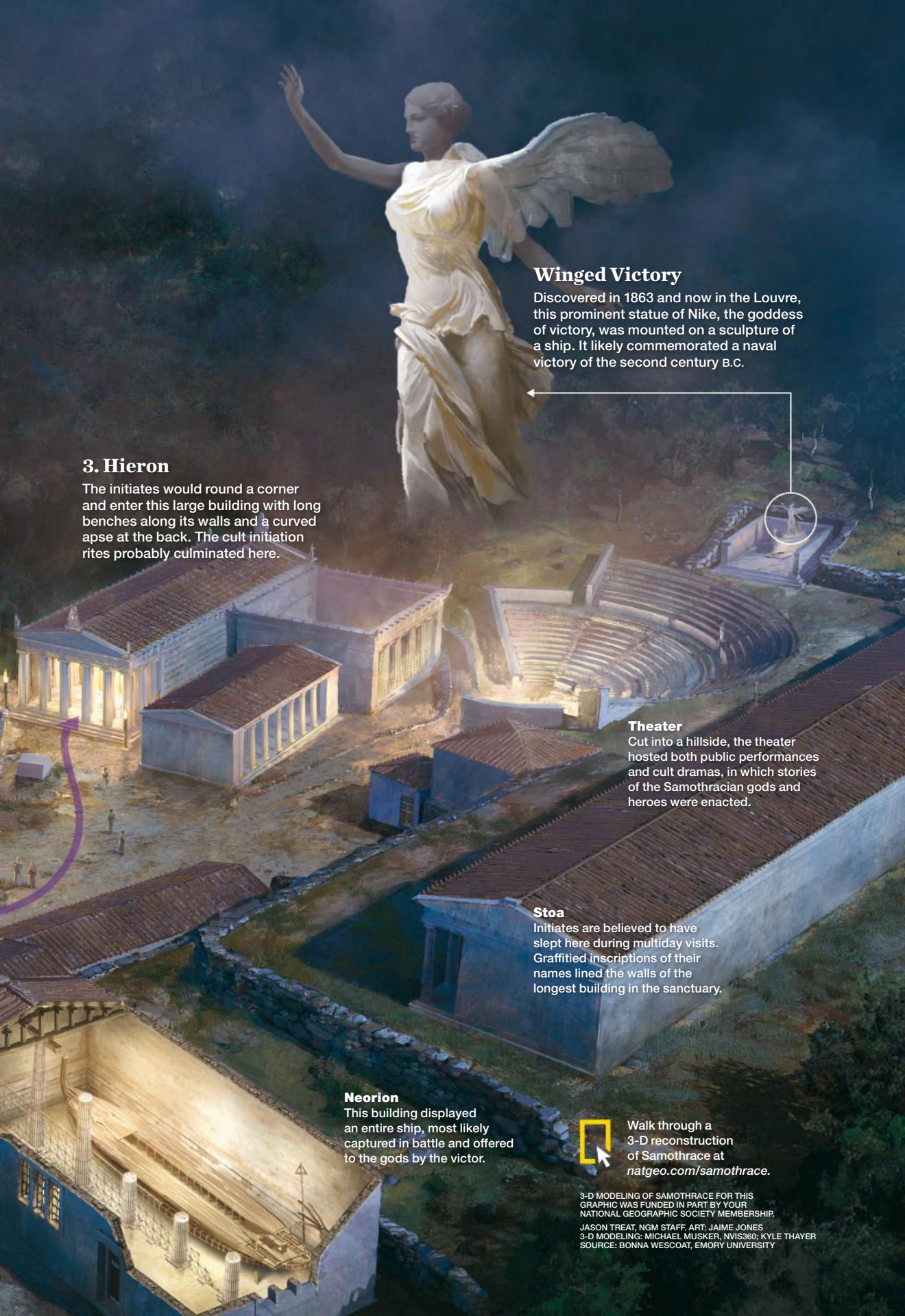


Musicians, a lamb for slaughter, and a woman holding altar utensils appear in this painting of a sacrificial procession. Religious ceremonies were among the few public events where women had roles.

DAVID COVENTRY, NATIONAL ARCHAEOLOGICAL MUSEUM, ATHENS

The Sacred Way

Greeks turned to mystery cults when seeking meaning in their individual lives and protection after death. At sites such as the sanctuary of the great gods, on the island of Samothrace, initiates were admitted to the cults in ceremonies whose details are still not fully known.



Winged Victory

Discovered in 1863 and now in the Louvre, this prominent statue of Nike, the goddess of victory, was mounted on a sculpture of a ship. It likely commemorated a naval victory of the second century B.C.

3. Hieron

The initiates would round a corner and enter this large building with long benches along its walls and a curved apse at the back. The cult initiation rites probably culminated here.

Theater
Cut into a hillside, the theater hosted both public performances and cult dramas, in which stories of the Samothracian gods and heroes were enacted.

Stoa
Initiates are believed to have slept here during multiday visits. Graffitied inscriptions of their names lined the walls of the longest building in the sanctuary.

Neorion
This building displayed an entire ship, most likely captured in battle and offered to the gods by the victor.

Walk through a 3-D reconstruction of Samothrace at *natgeo.com/samothrace.*

3-D MODELING OF SAMOTHRACE FOR THIS GRAPHIC WAS FUNDED IN PART BY YOUR NATIONAL GEOGRAPHIC SOCIETY MEMBERSHIP.

JASON TREAT, NGM STAFF. ART: JAIME JONES
3-D MODELING: MICHAEL MUSKER, NVIS360; KYLE THAYER
SOURCE: BONNA WESCOAT, EMORY UNIVERSITY

Power of the Dead

Believing that the dead could exert bad or good influence from the afterlife, ancient Greeks sought their ancestors' favor with honors and offerings. Many also believed that their own fate after death was directly related to their initiation into the right cults.

This marble relief on a grave served to preserve the memory of the departed: a young mother, whose baby is brought to her and reaches for her (above). Ancient Greeks believed that in the underworld, the deceased were brought before three judges. One was Rhadamanthus (right), shown here in a painting on a Macedonian tomb.

DAVID COVENTRY, NATIONAL ARCHAEOLOGICAL MUSEUM, ATHENS (ABOVE); VINCENT J. MUSI, TOMB OF MIEZA (RIGHT)

Which is better, life or the afterlife? In Homer's *Odyssey,* the slain hero Achilles answers from the underworld: "I would rather serve as laborer to a serf, to a landless man who has no great livelihood, than rule all the perished dead."

Ancient Greeks believed Charon the ferryman took souls to Hades across Acheron, the "river of woe." Today the river—here colored by lights from a nearby bar—is popular among tourists and rafters.

VINCENT J. MUSI

Smartphone Americana

Story and Photographs by
DAVID GUTTENFELDER

As an international photojournalist, I've been to some of the most far-flung places on Earth. After 20 years abroad, I felt like my own country was a mystery to me. So when I moved back to the United States in 2014, I began to explore it as I would explore any foreign country—with my camera. Only I didn't use a "real" one; I used my smartphone.

I've always kept a small film camera with me for my personal projects—things I wanted to shoot for myself, without the pressure of external expectations. When I got my first smartphone, in 2010, I realized it was the perfect tool for this kind of thing: small, discreet, always in my back pocket.

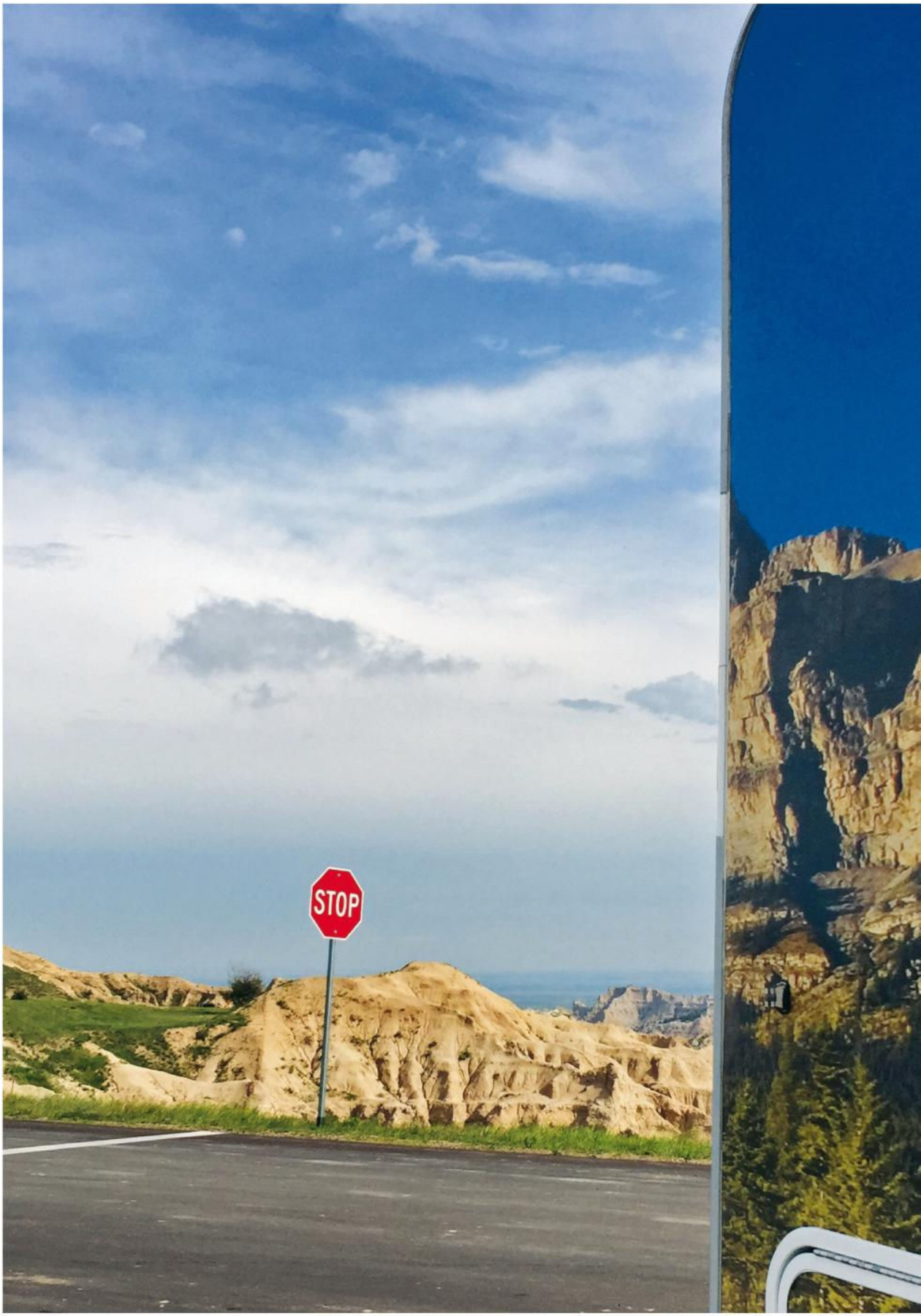
But back then it was considered a toy. When I took one to Afghanistan, I was told that it was inappropriate to cover a serious topic like war with a phone instead of a "professional" camera. Fast-forward to the present. With more than 400 million users on Instagram, it's a different world now. Photographing our lives with our phones has become a completely natural behavior.

Smartphones do present challenges and technical limitations. They're not as responsive as my regular cameras, and the optics aren't as sharp. But that's OK; I want my images to be imperfect and immediate, to capture something both fleeting and timeless about the America that I'm rediscovering.

We tend to think that photojournalism requires access to other worlds, but all you really have to do is document your own life. Mundane daily things are worthy of being noticed and celebrated. If we look closely, we can see that our own communities are just as compelling as the wildest places on the planet. □

During my first week back in the U.S., my sister hosted a Fourth of July party near Des Moines, Iowa. My niece decorated these strawberries with patriotic red, white, and blue frosting.

In Manhattan a sticky note heart affixed to an office window is a timeless symbol of life in New York (left). Yet many things changed in the United States during the time I lived abroad. For me the best surprise has been a new open-mindedness with regard to gay rights. At the intersection of 15th and P Streets in Washington, D.C., the 2014 Capital Pride Parade had a party atmosphere. One year later, the Supreme Court legalized same-sex marriage.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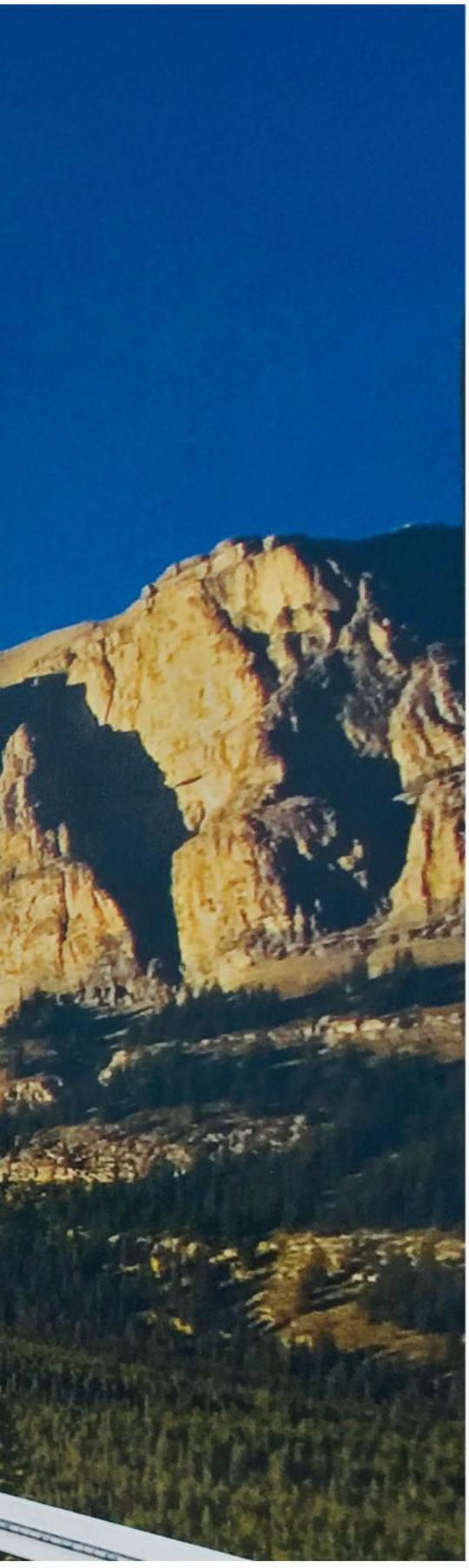
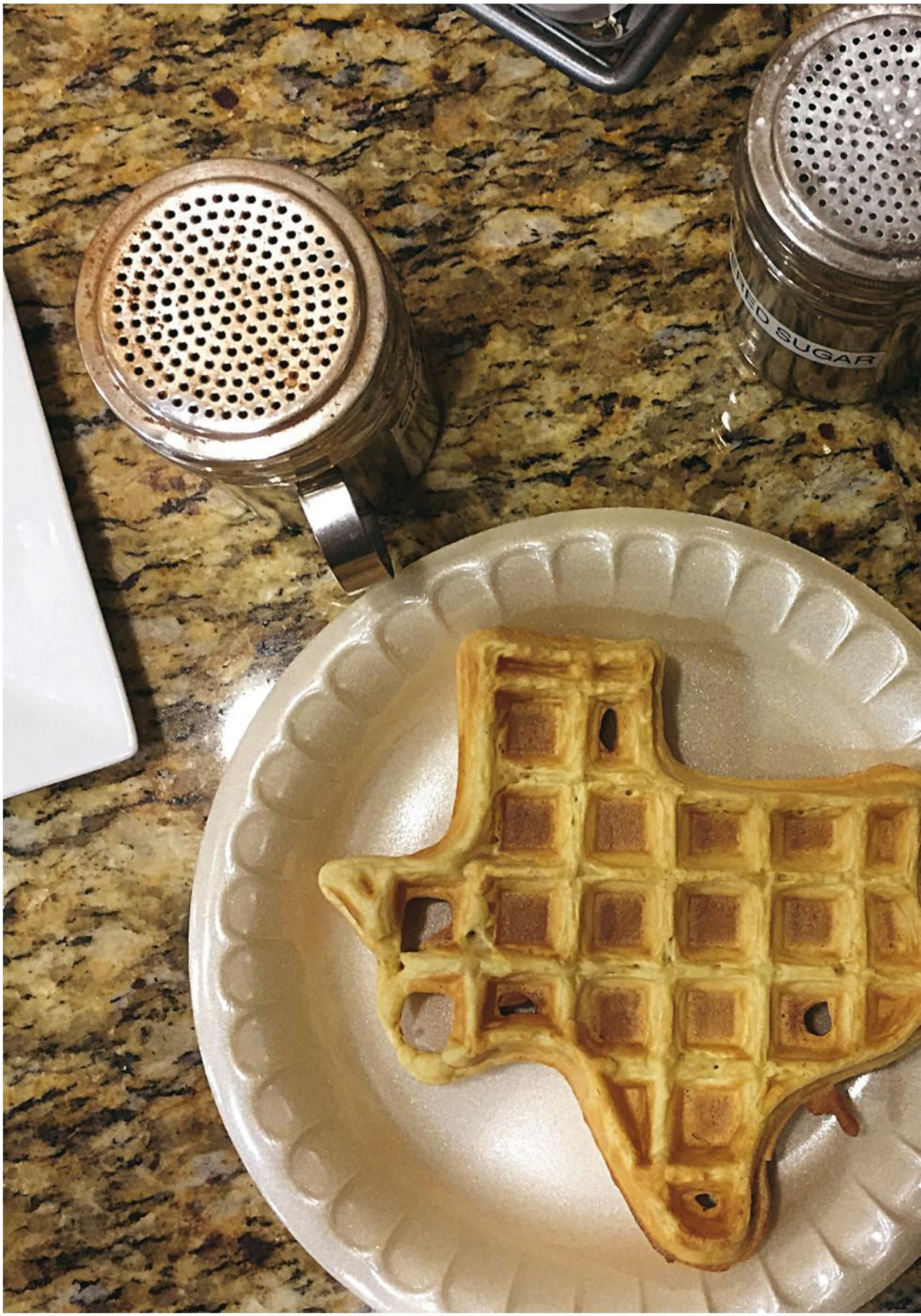


NGM MAPS

In the past two years I've visited many states, including Iowa (where I grew up), Minnesota (where I live now), and Wisconsin (where my family spends each summer). Everywhere I've gone, I've seen varied depictions of the American landscape. In this photo, a vista in South Dakota's Badlands is visible past the side of an RV camper emblazoned with similar scenery.


FOOT LONG
HAND DIPPED
CORN DOGS
Lemonade
BEER
FOOT LONG
CORN DOGS
Lemonade
CORN DOGS
HAND DIPPED

On a rainy night in Des Moines, state fairgoers stroll past refreshment stands (left). When I was a little boy, my parents opened a food stall—where they sold beef sandwiches called Maid-Rites—in this exact spot. In nearby Adel, my niece plays on a homemade waterslide during a Fourth of July party. My sister and her family live on a gravel road just a couple of miles from where we grew up. Photographing these places from my past feels both strange and appropriate. Maybe you *can* go home again.


ED SUGAR

I've been spending a lot of time in American hotels, most of which are pretty charmless and uninspiring. Morning buffets are usually on offer in the lobby, served with plastic-foam plates and disposable cups. So it was surprising to see—in this hotel breakfast in Houston—a burst of state pride in the shape of a waffle.

A Virtuous Vacation

James A. Bradley made his fortune selling brushes to the Union Army, but he found his true calling in the fresh air of the Jersey Shore. In 1871 the teetotaling Methodist bought 500 acres of marsh and sand dunes and built a new community called Asbury Park, molded to his strict moral code. Liquor was banned. Decency (detail, right) and family values were paramount.

Bradley mused that the seashore was the "nervine cureall" for those "whose nerves were shattered by too close application to their profession, studies, or their chase for the 'almighty dollar.'"

In the summer of 1929, eight years after his death, these vacationers can be seen taking his advice. By October the stock market would collapse, the Great Depression would begin—and the nerves shattered from chasing the almighty dollar would no longer be cured by a simple day in the sun. —*Eve Conant*

PHOTO: CLIFTON ADAMS, NATIONAL GEOGRAPHIC CREATIVE

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WHAT
PULLED
HAMMY?
Advil
Advil MAKES PAIN A DISTANT MEMORY.
Use as directed.
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